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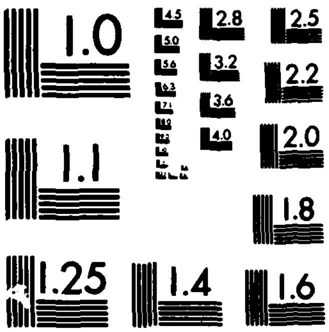

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U.S. Department of Transportation
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Establishment and Discontinuance Criteria for Airport Traffic Control Towers
Final Report

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16. Abstract
This report presents an economic analysis of VFR Airport Traffic Control Towers and criteria for tower establishment and discontinuance based on this analysis. Site-specific activity forecasts are used to develop tower benefits from prevented collisions between aircraft, other prevented accidents, and reduced flying time. Establishment costs include annual costs for staffing, maintenance, equipment, supplies and leased services and investment costs for facilities, equipment, and operational start up.

The present value of tower benefits are compared with the present value of tower costs over a fifteen-year time frame. A location meets tower establishment criteria when the benefits which derive from operating the tower exceed the costs; a tower meets discontinuance criteria, when the costs of continued operation exceed the benefits.

Applying the criteria to more than four-thousand airports, seventeen sites satisfy the benefit/cost criteria for tower establishment and fifty-five towers satisfy the benefit/cost criteria for discontinuance. These figures compare with twenty-five tower establishment candidates and forty-two tower discontinuance candidates under previous tower criteria.

The sensitivity of the criteria results to several key assumptions is also examined.

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EXECUTIVE SUMMARY

This report presents an economic analysis of the costs and benefits of Airport Traffic Control Towers and criteria for tower establishment and discontinuance based on this analysis. The analysis compares the present value of VFR tower benefits with the present value of VFR tower costs over a fifteen-year time frame. A location meets tower establishment criteria when the benefits which derive from operating the tower exceed the installation and operations costs--the benefit/cost ratio is greater than or equal to one. A tower meets discontinuance criteria, when the costs of continued operation exceed the benefits--the benefit/cost ratio is less than one.

Site-specific activity forecasts are used to develop the three categories of tower benefits:

- o Benefits from prevented collisions between aircraft
- o Benefits from other prevented accidents
- o Benefits from reduced flying time

Explicit dollar values are assigned to fatalities, injuries and time to provide a common basis for comparing costs and benefits.

Tower establishment criteria costs include:

- o Annual costs: staffing, maintenance, equipment, supplies and leased services
- o Investment costs: facilities, equipment, and operational start up

Tower discontinuance criteria use the same annual costs as the establishment criteria, but investment costs are replaced by the costs of shutting down the tower.

These criteria were applied to more than four-thousand airports in FAA's Terminal Area Forecast File. Seventeen sites satisfy the benefit/cost criteria for tower establishment; fifty-five towers satisfy the benefit/cost criteria for discontinuance. These figures compare with twenty-five establishment candidates and forty-two tower discontinuance candidates under previous tower criteria.

The sensitivity of the criteria results to several key assumptions is also examined in this report.

These criteria, as well as other criteria used in determining eligibility of terminal locations for establishment, discontinuance and improvements of air navigation facilities, equipment and services, are summarized in FAA Order 7031.2B, Airway Planning Standard Number One.

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I. INTRODUCTION

Good management of proposed capital investments requires analysis and comparison of benefits and costs. FAA evaluates its investments in navigation aids, communication aids, and control towers for the National Airspace System, by applying standard establishment and discontinuance "criteria." FAA's criteria are summarized in an FAA order, 7031.2B, called "Airway Planning Standard Number One - Terminal Air Navigation Facilities and Air Traffic Control Services" (Reference 1). For inexpensive devices, the criteria are simple traffic activity thresholds: an airport with 50,000 operations per year qualifies for an ATIS (Automatic Terminal Information Service), for example. Larger facilities, such as Airport Traffic Control Towers, have more complicated criteria, which require economic analysis of benefits and costs.

This report presents the economic analysis of costs and benefits of VFR Airport Traffic Control Towers and the criteria for tower establishment and discontinuance based on this analysis. Benefits for air traffic control services other than the VFR services provided at low activity towers, such as approach control services, are <u>not</u> included in the analysis of benefits. Other reports treat economic criteria for other elements of the National Airspace System. A more general discussion of benefit-cost analysis may be found in "Economic Analysis of Investment and Regulatory Decisions - A Guide" (Reference 2).

A. <u>Kinds of Benefits and Costs</u>

FAA's economic criteria are based on five kinds of benefits and two kinds of costs. Control towers yield several of these:

- <u>Safety</u> benefits stem from the assumption that most capital investments will reduce accidents. At airports where control towers are operating, midair collisions are less frequent, and fewer aircraft are damaged in landing accidents. Historical statistics at locations with and without towers may be used to calculate differential accident rates as a function of forecast activity at the airport. These rates are used to predict expected accidents, fatalities, injuries and property losses.

- <u>Aircraft operating costs</u> are avoided and <u>passengers' time</u> is saved when flight paths are shortened. Towers allow straight-in approaches. Like safety, these benefits increase with activity.

- Benefits for <u>avoided flight disruptions</u> are realized when an investment results in opening the airport to traffic when weather would otherwise have closed it. Benefits are calculated from the avoided cost of diverting flights to another airport. VFR control towers do not, in themselves, yield avoided disruption benefits.

- <u>Productivity</u> benefits result when an investment reduces required manpower. Tower controllers perform some functions which in their absence are performed by air carrier personnel.

- <u>Other</u> benefits can be qualitatively described, but cannot be quantified. Tower controllers may "save" lost pilots; knowledge of weather reported by a controller may convince a pilot to cancel a flight which would have crashed.

- <u>Investment</u> costs include the capital expenditure for the device, and whatever site improvements must be made to accommodate it. Costs are estimated for a particular site, so that airports with fewer siting or construction problems will have lower costs. In a discontinuance benefit-cost analysis, one-time costs of discontinuing operation are tallied.

- <u>Operations and maintenance</u> costs are estimated from both labor and materials costs.

B. <u>"Critical" Values and Activity Forecasts</u>

Explicit dollar values are assigned to fatalities, injuries and time to provide a common basis for comparing costs and benefits. Particular values for these as well as aircraft repair, replacement, and operating costs, were recommended by a 1981 report (Reference 3) and are now a part of Airway Planning Standard Number One. Critical values should be updated annually, insuring that the criteria reflect differences in the inflation rates of these values and costs.

Aviation activity projected in FAA's annual Terminal Area Forecasts is the independent variable for most benefit calculations. Values are computed for each of fifteen future years, discounted to present value with the ten percent rate directed by Office of Management and Budget, and summed to determine present value of costs and benefits over an expected fifteen year life. The useful life of the investment may be longer, but assuming a possibly shorter fifteen year life results in a more conservative investment strategy, and provides better protection against obsolescence due to technological or policy changes.

C. <u>How Criteria are Applied</u>

The benefit/cost criteria are applied in two phases, with the first phase being an abbreviated version of the second. The Phase I criteria are used by the FAA regional offices to initially screen locations for budget request submission. Phase II is the complete benefit-cost analysis. Both phases are described in this report.

Establishment criteria are used to evaluate investments at particular locations prior to Facilities and Equipment (F&E) budget submissions, or reprogrammings. Locations are considered "candidates" if they meet the Phase I criteria for three consecutive FAA annual counts. The Phase II benefit-cost analysis is used to evaluate candidates before they are submitted as budget requests. Meeting the economic criteria is usually a necessary condition for including a site in the budget. When the number of qualifying sites is larger than overall budget constraints will allow, some sites may not be funded, even if economically justified. The converse is also true: locations may be excepted from meeting the economic criteria because of other factors. For control towers some of these are terrain, severe weather, and site potential as a hub airport reliever.

Installations may be discontinued if the benefits fall below annual operation and maintenance costs, adjusted for any one-time shutdown costs. This can happen if activity levels drop, or reanalysis of benefits suggests that investments do not provide the same degree of benefit as previously believed.

D. Changes from Previous Criteria

This report, and the change to Airway Planning Standard Number One that will result from it, supersedes FAA reports ASP-75-4, "Establishment Criteria for Airport Traffic Control Towers" (Reference 4), and ASP-77-6, "An Analysis of Continued Operation of Selected Airport Traffic Control Towers" (Reference 5). Changes have been made to each of the benefit categories, costs of establishing control towers have been revised, critical values have been updated, and provision has been made for utilizing site specific activity forecasts.

E. Organization of This Report

Phase II benefit/cost criteria and simple Phase I criteria are presented in Chapter II. Complete details for the cost calculations are given in Chapter III, and for the benefit calculations in Chapter IV. The results of applying these criteria are presented in Chapter V. Chapter VI discusses development of the simple Phase I criteria. The sensitivity of the criteria results to several key assumptions and inputs is discussed in Chapter VII.

A manual method for calculating the Phase II benefit/cost ratio is presented in Chapter VIII. As a practical matter a computer program will be used to calculate these ratios. Chapter IX contains complete details concerning the use of this program, including a discussion of what site-specific values may be used.

II. AIRPORT TRAFFIC CONTROL TOWER CRITERIA

The VFR airport traffic control tower criteria outlined below are intended to replace the tower criteria currently contained in Order 7031.2B, Airway Planning Standard Number One (Reference 1). Previous criteria are discussed in References 4 and 5. Meeting the candidacy requirements does not mean automatic qualification for either control tower establishment or discontinuance. The benefit/cost criteria screening is but one of several inputs to the FAA decisionmaking process with regard to tower establishment.

The two phases of tower establishment and discontinuance criteria are described below.

A. Benefit/Cost Criteria (Phase II)

The Phase II criteria compare the present value of tower benefits with the present value of costs over a fifteen-year time frame, using site-specific activity forecasts to develop estimated benefits. The present values are then obtained by discounting the future costs and benefits to the present time at a compound rate and summing.

An investment is said to meet benefit/cost criteria when the ratio of benefits to costs is 1.0 or greater. This is the same as saying that values of benefits exceed costs. The investment fails to meet the criteria when this ratio is less than 1.0. Yet the approximations and assumptions inherent in the analysis suggest that investments (or possibilities for discontinuance) where the ratio is within 0.1 of 1, i.e., between 0.9 and 1.1, are "too close to call." Operational decisions in these cases should be made on other than economic bases.

1. Establishment Criteria: A site meets tower establishment criteria when the present value of control tower benefits, BPV, equals or exceeds the present value of establishment costs, CPV. This is usually stated in ratio form:

   $$BPV/CPV \geq 1.00$$

2. Discontinuance Criteria: A tower meets tower discontinuance criteria when the present value of the costs of continued operation exceed the present value of the benefits, i.e.

   $$BPV/CPV < 1.00$$

If continued tower operation is not economically justified, a site-specific analysis will be performed which shall include, but not be limited to:

- o Assurance that factors unique to the location such as weather and topography, are properly accounted for.
- o Potential use of the site to provide capacity and training relief for a hub airport.
- o Impact on adjacent facilities.
- o Operational factors which cannot otherwise be accounted for by the benefit-cost analysis
- o The possibiliy of significant changes in traffic activity attributable to unique local conditions.
- o Military requirements.

These are similar to factors in previous discontinuance criteria adopted in November 1981. (See Reference 1.)

B. Phase I Criteria

Phase I criteria use a ratio test based on one year's activity for three consecutive reporting periods to identify possible sites for tower establishment or discontinuance. These simple tests have been developed from the detailed Phase II benefit/cost analysis to identify potential candidates using simple hand calculations. Phase I establishment criteria use the following ratio sum derived from the latest annual operation counts reported for the site:

Let

AC = Air Carrier Operations
AT = Air Taxi Operations
GAI = General Aviation Itinerant Operations
GAL = General Aviation Local Operations
MI = Military Itinerant Operations
ML = Military Local Operations

Then

$$\frac{AC}{38{,}000} + \frac{AT}{90{,}000} + \frac{GAI}{160{,}000} + \frac{GAL}{280{,}000} + \frac{MI}{48{,}000} + \frac{ML}{90{,}000}$$

is the Phase I Establishment Ratio Sum. If this sum is greater than or equal to one, then the site becomes a candidate for tower establishment.

Thus a site with only general aviation activity needs between 160,000 and 280,000 operations per year - between 470 and 770 per day - depending upon the itinerant-local mix to generate sufficient benefits to cover the investment, operation and maintenance costs of a tower. On the other hand, 38,000 air carrier operations per year--about 100 per day--generate enough benefits to offset establishment costs.

For tower discontinuance, a different ratio sum is used:

$$\frac{AC}{15{,}000} + \frac{AT}{40{,}000} + \frac{GAI}{75{,}000} + \frac{GAL}{125{,}000} + \frac{MI}{20{,}000} + \frac{ML}{35{,}000}$$

A site becomes a discontinuance candidate if this sum, the Phase I Discontinuance Ratio Sum, drops below one.

The ratio-sum test for continuing to operate an established tower is less stringent than the establishment test, since the capital costs of building and equipping the tower are already sunk.

Although the Phase I and Phase II criteria usually yield the same results, there will be some cases where they do not agree. This may be particularly true for sites where predicted activity growth is significantly faster or slower than the national average (as discussed in Chapter VI). The purpose of the Phase I criteria is to provide a simple approximation to the Phase II benefit/cost ratio test to identify potential candidates for tower establishment or discontinuance. Phase II criteria verify economic justification for establishment or discontinuance. If the two phases do not agree, the activity forecast for the site should be carefully analyzed and corrected if necessary. Site specific values may be used in Phase II as discussed in Chapter IX.

III. TOWER COSTS

A. Tower Establishment Criteria Costs

Airport traffic control tower costs are given in Table 3.1. There are two categories of costs:

- o Annual costs: the costs of staffing, maintenance, equipment, supplies and leased services

- o Investment costs: the one time costs of facilities, equipment and operational start up

1. Annual Costs

Costs of operating and maintaining an airport traffic control tower for one year are given in Table 3.1. The normal air traffic staffing for a low activity control tower (operating 16 hours daily) is one Air Traffic Manager and six controllers. At such a facility, the 1980 salary for the average manager (GS 12 step 2)[1] is $25,526 [$29,187 in 1982], and for the average controller (GS 10 step 5)[1], $21,260 [$24,309 in 1982]. These salaries must be adjusted upward by 26 percent to account for the total cost to the government of retirement, health and other benefits (Reference 2, Chapter IV). No adjustment is included here for leave and other absences, since leave considerations are already included in the staffing requirement. Thus the effective compensation shown in the table is $32,163 for the chief and $26,788 for each of the controllers, for a total controller staffing cost of $192,889 [$220,552 in 1982].

Other annual costs for a low activity tower are shown in the table. The cost of airway facilities staff for a low activity tower was $22,915 in 1981, or $21,001 in 1980. Leased communications are $15,000 in 1982 which is equivalent to $12,990 in 1980$. Controller change of station costs for one controller every other year are 1/2 x $8300 or $4150 in 1980. Other costs for stocks and stores, rent, utilities, contracted services, related administrative costs and other objects totaled $9753 in 1982 which is equivalent to $8446 in 1980$.

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1 Source: AAT-130

Table 3.1
Tower Establishment Criteria Costs
(1980 Dollars)

	Cost	Total Cost
Annual Costs		
Staffing (including leave and benefits)		
Air Traffic[a]	$192,889	
1 Chief @ $32,163 6 Controllers @ $26,788 each		
Airway Facilities[b]	21,001	
Change of station costs (1/2 x $8300)[c]	4,150	
Leased communications[b]	12,990	
Other costs[b]	8,446	
Total annual costs		$ 239,476
Investment Costs		
Facilities and equipment[d]	$1,100,000	
Start up staffing		
Air Traffic[e]: $22,073 x 7 =	154,511	
Airway Facilities[f]	7,212	
Total investment costs		$1,261,723

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a Source: AAT-130

b Source: AAF-150

c Assuming one controller move approximately every two years and moving cost of $8300, the 1980 PCS national average from AAT-130

d Source: AAF-130

e Source: Table 3.2, this report

f Source: AAF-160

Table 3.2
Start-up Staffing Cost per Controller
(1980 Dollars)

		Cost ($1980)
Moving expenses		$8,300[a]
Training replacement controller		
Basic air traffic controller course	$1381	
Per diem during training	2784	
Travel to and from training	450	
Total		$4,615[b]
Trainee's salary costs		
Two weeks orientation plus 21 weeks training for one GS 7 times benefit and leave factors		$9,158
Total per controller		$22,073

a 1980 PCS national average from AAT-130

b Source: APT-330

2. Investment Costs

The primary investment cost of establishing a low activity tower is the facilities and equipment cost, estimated at $1.1 million in 1980. This figure includes all Airway Facility costs incurred from planning through the time that the equipment is installed and the tower is ready for operation. The other major cost of establishing a control tower is the "start-up" staffing costs, primarily transferring seven experienced controllers and training replacements for these seven controllers. The cost for one replacement controller, shown in Table 3.2, includes the cost of the basic air traffic control course at the FAA Academy, as well as associated travel costs and salary during the training period. The salary costs,

$$(23/52) \times \$13,926 = \$6160$$

are adjusted upward by 26 percent for retirement, health and other benefits. These costs must then be increased by an additional 18 percent for annual leave, sick leave and other absences (Reference 2, Chapter IV), since leave would be earned, but not normally used, during the training period. These items are included in the costs because they are a part of the employee's total compensation package. The resulting "start up" staffing cost is \$22,073 per controller--\$154,511 for the seven. An additional "start up" staffing cost is for training Airway Facilities' personnel, estimated at \$8250 in 1982, or \$7212 in 1980\$. The total investment cost is the sum of facilities, equipment, and start up staffing costs, \$1262 thousand.

3. Present Value

As discussed in Chapter II, tower benefits are compared with tower costs over a fifteen year time frame, by comparing present values. It is convenient to assume that investment costs all occur at the beginning of the time frame, so that their present value equals actual costs. We assume that annual costs will remain constant (in 1980 dollars) over the 15 years. In particular, this assumption implies that growth in traffic over the period will not be sufficient to require an increased staffing level. If additional staffing is anticipated for a particular location, then site-specific costs, which include appropriate staffing costs, should be used. Since the annual costs will be constant for each year in the time frame, the present value is simply some number times this constant value. In this case the number for 15 years at the ten percent discount rate prescribed by the Office of Management and Budget is 7.977.[2] Letting

COSTA = Annual costs

COSTE = Establishment investment costs

the present value of tower establishment costs, CPV, is given by

CPV = (7.977 x COSTA) + COSTE

CPV = (7.977 x \$239) + \$1262

CPV = \$1907 + \$1262

CPV = \$3169 (thousands of dollars)

---

2 The present value is $\sum_{i=1}^{15} \frac{1}{(1.10)^{i-0.5}} = 7.977$

Since costs vary considerably from site to site, the criteria have been designed so that site specific values may be used for some or all of the above costs. However, it is important to adjust these values for inflation so that they are in the same dollar units as the benefits (1980$ in this report).[3]

B. Tower Discontinuance Criteria Costs

The cost used in the tower discontinuance criteria is the cost of continuing to operate the control tower: the difference between the annual costs of operating the tower and the costs of not-operating the tower, i.e., shutting it down. The capital costs, the costs of shutting down the tower, are given in Table 3.3. The dismantling costs include moving and salvaging some equipment, and removing controls for some items left behind. Costs of actually tearing down the tower are not included. The annual costs of continuing to operate the tower, also given in the table, are the same as for the establishment case.

Table 3.3
Tower Discontinuance Criteria Costs
(1980 dollars)

	Cost	Total Cost
Annual Costs of Continued Operation		
Total annual costs from Table 3.1		$239,476
Decommissioning Costs		
Dismantling	$60,000[a]	
Relocating controllers - moving expenses for seven controllers ($8300 x 7)	$58,100[b]	
Total decommissioning costs		$118,100

a Source: AAF-530

b Source: AAT-130

3 See Reference 2, Chapter 7, for additional information on making these adjustments

Thus if we let

COSTD = Decommissioning costs

then the present value of the costs of continuing to operate the tower over the fifteen year time frame, CPV, is given by

CPV = (7.977 x COSTA) - COSTD

CPV = (7.977 x \$239) - \$118

CPV = \$1907 - \$118

CPV = \$1789 (thousands of dollars)

Both annual and investment costs for the discontinuance case probably vary even more from site to site than for establishment. For example, while most new towers are staffed with one manager and six controllers, some potential discontinuance candidates might use as many as ten or as few as four controllers. In such cases site-specific annual cost values may be obtained by changing the appropriate entries in Table 3.1. Decommissioning costs should reflect all shut-down costs anticipated at that site. For example, if a tower is temporarily closed, the controller relocation costs shown in Table 3.3 should be eliminated and actual dismantling costs, if any, should be used. Any relocation, renovation, or modernization costs required to continue operating the tower over the 15-year benefit-cost analysis period should also be included as capital costs.

Site-specific costs should be used where available. These costs must be adjusted for inflation so that they are in the same units as the benefits (1980\$ in this report).[4] Anticipated future capital costs should also be appropriately discounted.

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4 See Reference 2, Chapter 7, for details about adjusting for inflation.

IV. TOWER BENEF.TS

The primary responsibility of the VFR tower controller is to provide aircraft sequencing in the air and separation on the ground. Controllers determine aircraft position and issue control instructions and clearances to pilots to accomplish these responsibilities. Controllers determine aircraft position from pilot reports and by directly observing aircraft. Clearances issued by controllers for purposes of sequencing and separation are binding on pilots, unless the pilot refuses the clearance.

A secondary responsibility is to expedite the flow of traffic. Normal safety procedures used in the absence of a control tower, such as entering and flying in the airport traffic pattern and overflying the airport to determine such information as wind direction and airport obstructions, result in additional flying time for aircraft landing at nontowered airports.

While controllers may direct pilots only for air traffic control purposes, they are well positioned to advise the pilot on matters such as adverse weather, obstructions on the airport site, or landing gear not extended. Controllers can also summon aid for pilots when needed, such as equipment for firefighting or search and rescue. Thus, the total safety benefits of VFR towers derive from more than the primary function of sequencing traffic.

Tower benefits will be considered in three main categories:

B1: Benefits from prevented collisions between aircraft.

B2: Benefits from other prevented accidents.

B3: Benefits from reduced flying time.

In addition to these three benefits, there is a fourth benefit which could be termed subjective:

B4: Direct and indirect economic benefits to the community and benefits due to the facility being part of the larger overall system.

For a proposed tower establishment or discontinuance site, the tower benefits B1 thru B3 for each year of the 15-year time frame are based on actual and projected operation counts from FAA's Terminal Area Forecasts (Reference 6). Total annual operations for the following aircraft classes are used:

1. AC: air carrier
2. AT: air taxi
3. GAI: general aviation - itinerant
4. GAL: general aviation - local
5. MI: military - itinerant
6. ML: military - local

The details of the derivation of each of the benefits are described in the following sections.

A. Benefits from Prevented Collisions between Aircraft

An evaluation of the effectiveness of air traffic control towers in reducing the risk of collisions between general aviation aircraft is described in Reference 7. All collisions between general aviation aircraft (including air taxi aircraft) occurring within airport air traffic areas for the years 1969 thru 1978 were included in this analysis except collisions involving:

- o Air carrier or military
- o Helicopters or seaplanes
- o Intentional close proximity flying (such as crop dusting or fish spotting)

Two categories of collisions were considered:

1. Collisions in which one or both aircraft were airborne
2. Collisions in which both aircraft were on the ground

For both categories the annual number of collisions between aircraft at both towered and non-towered airports was found to be directly proportional to the number of "potential collision pairs." The number of potential collision pairs is the mathematical combination of the number of aircraft taken two at a time, which is approximately equal to the square of the annual operations divided by two.[1] The following

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[1] The number of combinations of two elements that can be drawn from a set of n elements is $n(n-1)/2$. For large n, this is approximately equal to $n^2/2$.

functional relationship between the annual number of collisions and the square of the annual operation count represent statistical "expected" or "mean" values:

1. The expected number of collisions at towered airports in which one or both aircraft were airborne is for towered airports

$$CA_T = 0.456 \times (OPS/10^6)^2$$

and at non-towered airports

$$CA_{XT} = 5.128 \times (OPS/10^6)^2$$

where

$$OPS = \text{total annual operations}$$

Thus a tower may be expected to prevent

$$CA_{XT} - CA_T = 4.672 \times (OPS/10^6)^2$$

collisions, with one or both aircraft airborne, per year.

2. The expected number of collisions on the ground at towered airports is

$$CG_T = 0.644 \times (OPS/10^6)^2$$

and at non-towered airports

$$CG_{XT} = 2.656 \times (OPS/10^6)^2$$

Thus a tower may be expected to prevent

$$CG_{XT} - CG_T = 2.012 \times (OPS/10^6)^2$$

collisions that occur on the ground per year.

Statistical confidence limits on differences in the number of collisions at towered and non-towered airports were also obtained, as discussed in Appendix B. Upper 95-percent confidence limits on the differences in the number of collisions at non-towered and towered airports are

1. with one or both aircraft airborne

$$10.51 \times (OPS/10^6)^2$$

2. and with both aircraft on the ground

$$6.95 \times (OPS/10^6)^2$$

Supporting economic assessment generally assigns mean or expected values for parameters used in the computation of benefits and costs. In the case of tower establishment, we use mean collision potential estimates with the realization that other, more pessimistic or optimistic values may be substituted where on-site circumstances dictate. For tower discontinuance, however, we do not normally know, nor can we ascertain, the relative likelihood of collision occurrence in the absence of the tower. In the absence of this requisite site-specific data, it appears both logical and prudent to conservatively use confidence limit values rather than mean values to assess the safety impact of existing towers.

Although the results above only apply to general aviation aircraft (including air taxi) these accident functions are also applied to the other aircraft categories[2], air carrier and military, since there are simply not enough data to obtain independent functions for these aircraft types. How the formulas above are extended to the six aircraft classes is explained in Appendix B. For each class i, there are

$$2 \times R1 \times OPSM(i) \times OPSALL$$

class i aircraft (two aircraft in each collision) where

R1 = a collision coefficient from Table 4.1

OPSM(i) = total operations for aircraft class i <u>in millions</u> from Terminal Area Forecasts

Table 4.1

Coefficients Used to Calculate Differences in Number of Collisions Without and With Towers (Per Million Operations)

Collision Type	Establishment Mean Value[a]	Discontinuance Upper Bound[b]
One or both airborne - RCA	4.672	10.51
Both on ground - RCG	2.012	6.95

a From Reference 7

b From Appendix B

2 This same approach was used in the previous air traffic control tower criteria.

$$OPSALL = \sum_{i=1}^{6} OPSM(i) \text{ (also in millions)}$$

The collision functions above are used to predict expected numbers of fatalities and injuries and expected property losses. For example, the number of fatalities in collisions between aircraft is the product of the number of aircraft and the number of fatalities per aircraft--the fraction of occupants killed per aircraft times number of occupants. Thus the number of fatalities in class i aircraft is

$$FCA(i) = 2 \times (RCA \times OPSM(i) \times OPSALL) \times (CAIF \times LO(i))$$

in collisions with one or both aircraft airborne, and

$$FCG(i) = 2 \times (RCG \times OPSM(i) \times OPSALL) \times (CGIF \times LO(I))$$

in collisions with both aircraft on the ground, where

RCA = coefficient for collisions for one or more aircraft airborne from Table 4.1

RCG = collision coefficient for both aircraft on the ground from Table 4.1

CAIF = fraction of occupants killed in collisions with one or both aircraft airborne from Table 4.2

CGIF = fraction of occupants killed in collisions with both aircraft on the ground from Table 4.2

LO(i) = average number of occupants aboard class i aircraft from Table 4.3

The number of fatalities in class i aircraft a tower may be expected to prevent is the sum of the fatalities in the two collision categories:

$$FAC(i) + FCG(i) = 2 \times (RCA \times CAIF + RCG \times CGIF) \times OPSM(i) \times OPSALL \times LO(i)$$

The total number of fatalities in all collisions a tower may prevent in one year is obtained by summing over the six aircraft classes:

$$IF1 = \sum_{i=1}^{6} 2 \times (RCA \times CAIF + RCG \times CGIF) \times OPSM(i) \times OPSALL \times LO(i)$$

The expressions for the number of serious injuries, IS1, and the number of minor injuries, IM1 are analogous to the above:

Table 4.2

Injury Severity and Damage Severity Fractions in Collisions Between Aircraft[a]

	One or Both Airborne		Both on Ground	
Injury Severity	**Name**	**Value**	**Name**	**Value**
Fatal	CAIF	0.210	CGIF	0.047
Serious	CAIS	0.079	CGIS	0.011
Minor	CAIM	0.064	CGI5	0.004
None	-	0.646	-	0.939
Damage Severity				
Destroyed	CADS	0.347	CGDS	0.096
Substantial	CADM	0.526	CGDM	0.740
Minor/None	-	0.126	-	0.164

a From Reference 7

Table 4.3

Values for Critical Values by Aircraft Class Used to Calculate Collision and Accident Benefits[a]

	Aircraft Class	Number of Occupants LO(i)	Value Aircraft Destroyed ($K) VDS(i)	Value Aircraft Substantially Damaged ($K) VDM(i)
1.	Air Carrier	40.44	$2771	$924
2.	Air Taxi	5.42	137	46
3.	General Aviation-Itinerant	2.90	56	19
4.	General Aviation-Local	1.99	56	19
5.	Military-Itinerant	4.39	1400	470
6.	Military-Local	4.39	1400	470

a From Appendix A

$$IS1 = \sum_{i=1}^{6} 2 \times (RCA \times CAIS + RCG \times CGIS) \times OPSM(i) \times OPSALL \times LO(i)$$

$$IM1 = \sum_{i=1}^{6} 2 \times (RCA \times CAIM + RCG \times CGIM) \times OPSM(i) \times OPSALL \times LO(i)$$

where

CAIS, CAIM = fraction of occupants sustaining serious, minor injuries in collisions with one or both aircraft airborne from Table 4.2.

CGIS, CGIM = fraction of occupants sustaining serious, minor injuries in collisions with both aircraft on the ground from Table 4.2.

Similar expressions are developed to estimate the number of destroyed or substantially damaged aircraft which would be prevented by installing a tower. The number of class i aircraft destroyed, for example, is the product of the fraction of aircraft destroyed (Table 4.2) and the number of aircraft involved in collisions:

$$2 \times (RCA \times CADS + RCG \times CDGS) \times OPSM(i) \times OPSALL$$

where

CADS, CDGS = fraction of aircraft destroyed in the corresponding collision category from Table 4.2

To obtain the dollar value of all aircraft destroyed in collisions, DS1, the product of the number of class i aircraft and the value of the class i aircraft (Table 4.3) are summed over the six aircraft classes:

$$DS1 = \sum_{i=1}^{6} 2 \times (RCA \times CADS + RCG \times CGDS) \times OPSM(i) \times OPSALL \times VDS(i)$$

and similarly, the dollar value of all aircraft substantially damaged in collisions, DM1, is.

$$DM1 = \sum_{i=1}^{6} 2 \times (RCA \times CADM + RCG \times CGDS) \times OPSM(i) \times OPSALL \times VDM(i)$$

where

> VDS(i), VDM(i) = dollar value of destroyed, substantially damaged aircraft of class i from Table 4.3
>
> CADM, CDGM = fraction of aircraft substantially damaged in the corresponding collision category from Table 4.2

The annual benefit from prevented collisions between aircraft, is the sum of the dollar values of the differences between expected fatalities, injuries and property losses without a tower and with a tower:

$$B1 = (IF1 \times VF) + (IS1 \times VS) + (IM1 \times VM) + DS1 + DM1$$

where

> VF, VS, VM = dollar value of one fatality, $530,000; serious injury, $38,000; minor injury, $15,000 (from Appendix A)

Chapter VIII contains a worksheet designed for manual computation of B1 (Figure 8.2), which shows the above calculations in tabular form and includes the values for all the variables above for each aircraft class. An illustrative calculation is also provided (Figure 8.8).

B. Benefits from Other Tower Preventable Accidents

In addition to collisions between aircraft, other kinds of accidents may occur with lower frequency at towered airports.

Two techniques have been used to estimate the number and value of accidents preventable by a tower. The first technique is based upon an analyst's review of detailed accident records, and the judgmental determination as to whether or not a tower could have prevented that accident. For example, pilots who crashed with landing gear retracted might have corrected their error if the tower had observed it. Such accidents are deemed preventable in daylight but not at night when a controller cannot see the gear. The accidents which are judged avoidable and which occurred at non-towered airports are counted, and divided by operations counts at non-towered airports to yield a preventable accident rate.

A second technique does not rely on analytical judgment, but counts the accidents in particular categories which occurred at the towered and non-towered airport groups. A rate per operation is derived for each group, and the difference yields a rate for preventable accidents.

A difficulty with the first technique is that the judgment is largely subjective and relies on standard accident reports which may not contain sufficient information to draw an inference. The second technique, used to compare accident rates at towered and non-towered airports (Reference 8), corrects for this difficulty. However, as pointed out in the reference, the accident rate difference is not just because of the tower but because of differences in the total physical and operational environment between towered and non-towered airports. For example, towered airports typically have multiple runways, more paved runways, runway lights, landing aids (ILS, VASI, REIL and approach lights) and more UNICOM service available. Furthermore, there appear to be differences in the level of pilot experience as well as the types of aircraft. Thus while this specific analysis is not useful to us in determining the safety impact of the tower by itself, it does tend to show that there is a difference.

FAA is now conducting research to disaggregate overlapping contributions of the various facilities and equipment to accident prevention. If successful, this research will result in a far better estimate of tower preventable accidents than is now available.

Until then, Reference 9 provides the estimates used in this study. This reference combines the two techniques above. Accidents from 1964 to 1968 were examined in detail, and the inappropriate ones deleted without consideration of whether a tower was operating. Then the difference in rates between the group of non-towered and towered airports was obtained. While it would have been desirable to update the analysis with more recent accidents, it was estimated that the errors due to wrongly ascribing an avoided accident to a tower far outweighed the error due to an older sample.

Reference 9 reports seven categories of accidents which occurred with lower frequency at towered airports than at nontowered airports:

1. Wheels-up landings (with and without malfunction in the wheels-up warning systems). Theoretically, an accident could be prevented if the pilot is warned by the controller of the gear retraction. No wheels-up landings occurring during the nighttime were included.

2. Collisions of aircraft with objects other than aircraft. Other objects include construction barriers or other unusual hazardous objects of which the controller could warn the pilot. When the accident seemed to be due to pilot error which a controller could not or would not anticipate (e.g., colliding with parked aircraft), the accident was not selected for the analysis.

3. Landing on wrong runway relative to existing wind. This category includes cases where the aircraft landed in the wrong direction relative to the wind.

4. Not aligned with the runway (or intended landing area). The tower controller could theoretically spot an aircraft in danger of landing off the runway and warn the pilot of the erroneous heading.

5. Overshoots.

6. Undershoots.

7. Aircraft collisions when one or both aircraft are on the ground.

The reference reports five year average accident rates for each category. In using those rates in this analysis, the seventh category was excluded since collisions with another aircraft on the ground were included in the collision analysis, and therefore in B1. The resultant mean values are 9.704 accidents per million operations at non-towered airports vs. 4.538 accidents per million at towered airports, a difference of 5.166 accidents per million operations. Using a statistical T-test, this difference in accident rates was found to be statistically significant at the 0.01 level.

As in the collision analysis, we conservatively use statistical confidence limits on the number of accidents in discontinuance criteria, whereas mean values are used in establishment criteria. The upper 95-percent confidence limit for the difference in the number of accidents which a tower might prevent in one year (from Appendix C) is

$$7.595 \times OPSM(i)$$

compared to the mean value for one year of

$$5.166 \times OPSM(i)$$

where

OPSM(i) = total operations for class i aircraft in millions.

The above accident functions are used to compute benefits for each aircraft class except air carrier. Air carrier pilots are required to have radio communication with ground personnel, who are able to observe some of the conditions which lead to these accidents. But such personnel would not normally have as good a view of the airport environment as a controller would, and after providing an initial traffic advisory, there is little further visual contact. Thus, the service is not as effective as a tower in preventing some of these accidents. Since no data are available to calculate air carrier accident rates for these accident types, one half of the rate used for other classes is estimated for air carriers.

If we assume that the fractions of occupants killed and injured, and also the fraction of aircraft damaged and destroyed, for the entire set of accidents in the first six accident categories are valid for the subset of those accidents which are tower-preventable, then these fractions can be updated from the National Transportation Safety Board (NTSB) computer files. By screening these accident files, updated values for these fractions were obtained as discussed in Appendix C. These values are applied to the rate difference to calculate a benefit for accidents avoided due to tower operation.

The annual benefit from other tower preventable accidents, B2, is the sum of the dollar values of the additional fatalities, injuries, and property losses expected to occur if no tower is installed or an existing tower is discontinued:

$$B2 = (IF2 \times VF) + (IS2 \times VS) + (IM2 \times VM) + DS2 + DM2$$

where

IF2, IS2, IM2 = expected number of fatal, serious and minor injuries in tower-preventable accidents (calculated below)

VF, VS, VM = dollar value of one fatality, \$530,000; serious injury, \$38,000; minor injury, \$15,000 (from Appendix A)

DS2, DM2 = dollar value of destroyed, damaged aircraft in these preventable accidents (calculated below)

The expressions used to calculate IF2, IS2, IM2, DS2, DM2 are similar to the corresponding expressions for B1, except that the number of accidents is equal to the number of aircraft involved. For example, the number of fatalitites in class i aircraft is the product of the number of aircraft and the number of fatalities per aircraft--the fraction of occupants killed per aircraft times the number of occupants per aircraft:

$$(R2(i) \times OPSM(i)) \times (FIF2(i) \times LO(i))$$

where

R2(i) = tower preventable accident rate from Table 4.4

FIF2 = fraction of occupants killed from Table 4.5

LO(i), OPSM(i) are as defined above

The total number of fatalities in tower preventable accidents in one year is obtained by summing over the six aircraft classes:

$$IF2 = \sum_{i=1}^{6} R2(i) \times FIF2(i) \times LO(i) \times OPSM(i)$$

Similarly,

$$IS2 = \sum_{i=1}^{6} R2(i) \times FIS2(i) \times LO(i) \times OPSM(i)$$

Table 4.4

Tower Preventable Accident Rates
(Per Million Operations)

	Class 1	All Other Classes
Mean value[a]	2.583	5.166
Confidence limit[b]	3.798	7.595

a From Reference 9 (adjusted)

b From Appendix C

$$IM2 = \sum_{i=1}^{6} R2(i) \times FIM2(i) \times LO(i) \times OPSM(i)$$

$$DS2 = \sum_{i=1}^{6} R2(i) \times FDS2(i) \times OPSM(i) \times VDS(i)$$

$$DM2 = \sum_{i=1}^{6} R2(i) \times FDM2(i) \times OPSM(i) \times VDM(i)$$

where

FIS2(i), FIM2(i) = fraction of occupants sustaining fatal, serious and minor injuries from Table 4.5

FDS2(i), FDM2(i) = fraction of aircraft destroyed, substantially damaged from Table 4.5

VDS(i), VDM(i) are as defined above (Table 4.3).

C. Benefits from Reduced Flying Time

A control tower can make a more efficient approach and landing possible for an aircraft resulting in savings of aircraft operating costs and passengers' time. For example, some aircraft would have to overfly a non-towered airport to obtain such information as wind direction and

Table 4.5

Values for Injury and Damage Fractions used to Calculate Accident Benefits[a]

Aircraft Class	Fraction Fatalities FIF2(i)	Fraction Serious Injuries FIS2(i)	Fraction Minor Injuries FIM2(i)	Fraction Aircraft Destroyed FDS2(i)	Fraction Aircraft Substantially Damaged FDM2(i)
1. Air Carrier	0.0871	0.0337	0.0504	0.1736	0.7917
2. Air Taxi	0.0567	0.0565	0.0962	0.1273	0.8712
3. General Aviation-Itinerant	0.0329	0.0497	0.0992	0.1007	0.8962
4. General Aviation-Local	0.0329	0.0497	0.0992	0.1007	0.8962
5. Military-Itinerant	0.0448	0.0531	0.0977	0.1140	0.8837
6. Military-Local	0.0448	0.0531	0.0977	0.1140	0.8837

a From Appendix C

traffic which would be available from a controller at a towered airport. Furthermore the controller can clear an aircraft for a straight-in approach because he has knowledge that there is no conflicting traffic. At a non-towered airport the usual procedure would be for a pilot to enter the airport traffic pattern, which would result in additional flying time for many aircraft. The benefits from reduced flying time, B3, consist of these two categories--avoided overflying and avoided traffic pattern flying.

1. Overflying

We first derive the amount of additional time required for overflying each year. Before attempting a landing, the pilot must obtain such information as wind direction, obstructions, and traffic. If there is no tower, UNICOM or Flight Service Station, the pilot will usually overfly the airport to obtain this information. However, a pilot approaching an airport when the wind is greater than 15 knots would usually have some other way to determine wind direction (Reference 10), and will probably not overfly the airport.

We further assume that most local flights will already have the required information, and will not overfly. Neither will IFR flights, since an instrument approach at a non-towered airport is usually "straight-in." Furthermore, air carriers are required to have air-ground radio communication to obtain this same information, and would rarely, if ever overfly an airport.

For other itinerant aircraft classes i, the number of aircraft which overfly when there is no tower is the product of

- o number of landings (half the number of itinerant operations = OPS(i)/2)
- o fraction of landings with wind less than 15 knots[3] (0.89)
- o fraction of landings in visual conditions[3] (0.9744)
- o fraction of time UNICOM is not operating[3] (0.30)

Thus annual number of class i aircraft which overfly is

$$0.89 \times 0.9744 \times 0.30 \times OPS(i)/2 = 0.130 \times OPS(i)$$

In other words, overflying is associated with approximately 13 percent of the operations (26 percent of the landings).

3 From Reference 10

The additional time required to overfly an airport is approximately 1.5 minutes[4] or 0.025 hours for all itinerant flights but air carrier. Thus annual additional overflying time for air taxi, itinerant general aviation and itinerant military aircraft, classes 2, 3 and 4, is given by

$$0.130 \times OPS(i) \times 0.025 \text{ hours} = 0.00325 \times OPS(i) \text{ hours.}$$

Because this overflying will not occur in the presence of a nearby flight service station (FSS), the overflying time is set to zero in that case.

2. Traffic Pattern Flying

We now derive the additional time required to enter and fly in the airport traffic pattern at a non-towered airport. Figure 4.1 gives an example of a typical active runway and traffic pattern configuration. Aircraft approaching between A and D or D and C will simply enter the traffic pattern with no additional flying time required. However aircraft approaching between A and B which could make the shortest approach under positive control will need additional time to fly over to enter the upwind leg and then fly the entire upwind leg and the remainder of the traffic pattern. This will require from one to two minutes additional flying time.

Aircraft approaching between B and C will have to fly the upwind, crosswind, and downwind legs instead of making a more direct approach. This will result in between zero and one minute additional flying time. If we assume a uniform distribution of aircraft approaching the airport from all directions, then the amount of additional flying time will average

1/2 minute or 1/120 hours.

Case (a): If there is a flight service station, hence no overflying, then the itinerant arrivals

$$OPS(i)/2$$

will fly an additional

$$(OPS(i)/2) \times (1/120 \text{ hours}) = 0.00417 \times OPS(i)$$

hours in one year.

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4 From Reference 4

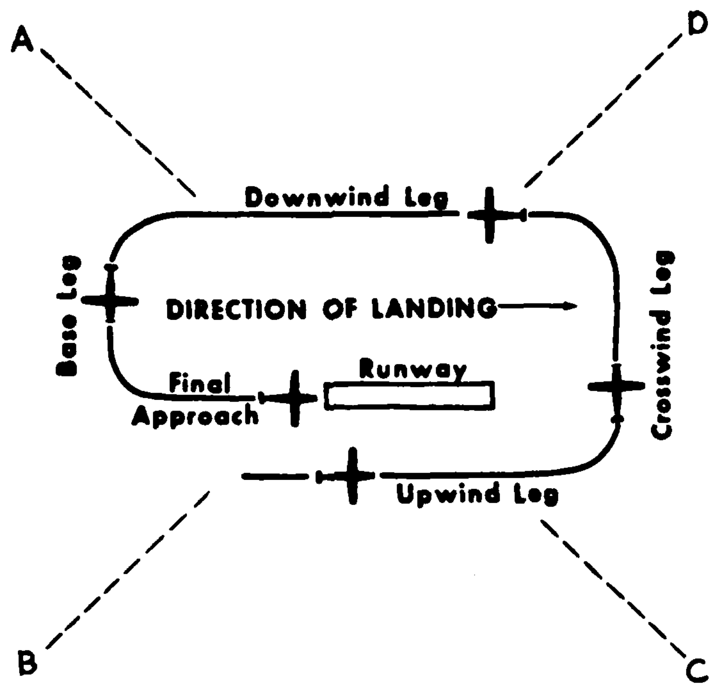

Figure 4.1. Example of Airport Traffic Pattern

Case (b): If there is no flight service station, the 26 percent of the itinerant arrivals which overfly will not require the additional traffic pattern time since this time is already included in the overflying time. Thus the remaining 74 percent arrivals will have the additional one-half minute time in the traffic pattern. Thus,

$$0.74 \times (OPS(i)/2) = 0.37 \times OPS(i)$$

aircraft will fly

$$(0.37 \times OPS(i)) \times (1/120 \text{ hours}) = 0.00308 \times OPS(i)$$

hours each year.

3. Sum of Reduced Flying Time

The total reduced flying time for the two cases is summarized below:

Case (a): The additional flying time at a non-towered airport with no FSS is

0.00325 x OPS(i) hours for overflying
0.00308 x OPS(i) hours for traffic pattern
0.00633 x OPS(i) hours total

Case (b): With a nearby FSS, additional flying time is

0.00417 x OPS(i) hours total (for traffic pattern only)

This additional time is not assigned to air carrier or local operations.

4. Converting to Monetary Units

To obtain the benefit from reduced flying, B3, the reduced flying time is calculated for each of the three itnerant class used, 2, 3 and 5, and multiplied by the "value" of flying the aircraft for one hour. The average "value" of flying a class i aircraft for one hour, VHR(i), is the sum of the variable operating cost for one hour, VO(i), and the product of the number of passengers, LP(i), times the value of passengers' time, VT:

$$VHR(i) = VO(i) + (LP(i) \times VT)$$

The values for VO(i), LP(i) and VT are given in Appendix A. Thus

$$B3 = (TIME \times OPS(2)) \times VHR(2) + (TIME \times OPS(3)) \times VHR(3) + (TIME \times OPS(5)) \times VHR(5)$$

where

TIME = additional flying time coefficient from above: 0.00633 if no nearby FSS, 0.00417 for nearby FSS

D. Other Benefits

These benefits which are considered nonquantifiable include benefits to the total system, providing advance information to other facilities and aircraft, providing emergency in-flight assistance, participating in search and rescue activities, acting as communication centers in times of natural disasters, stimulating the local economy, etc. Previous criteria estimated that these benefits amounted to about 20 percent of the total of the first three benefits. While acknowledging that these other benefits are valid ones, we do not attempt to quantify them. Thus B4 = 0 in this analysis. A sensitivity analysis which shows the impact of continuing to use the 20 percent factor for other benefits is given in Chapter VII.

In order to conduct operations at a non-towered airport, an air carrier must be furnished local traffic advisory information from an air/ground radio communications facility located in a position from which the operator is capable of observing local traffic and issuing traffic advisories (Reference 11). This means that the air carrier must have a trained observer on site as well as the communications equipment. Thus an additional tower benefit, not considered in this analysis, derives from not having to provide this service. For the small number of air carrier operations at non-towered airports, the costs of this service are not significant, because the work is a collateral duty for someone who would be on site for ticket taking, baggage handling, etc. For very large numbers of air carrier operations--many more than is typical of airports qualifying for towers--the work avoided by a tower could have a benefit of avoided salary to the air carrier.

E. Adjusting Benefits to Account for Hours of Operation

It is important, at this point, to make some adjustments to account for differences between benefit calculations for establishment criteria and decommissioning criteria. We first note that the operations data from the TAF file, used to calculate tower benefits, represent 24 hours per day at non-towered airports, but only the hours when the tower is operating at towered airports.

In calculating the benefits of establishing a control tower, then, the above benefit calculations must be modified to represent the fact that new towers will only operate 16 hours per day. At a sample of seven airports, we found that 92.5 percent of the operations occurred in the busiest 16 hour period (Reference 12). Thus there would be no benefit to the 7.5 percent of the operations occurring in the other eight hours. Therefore, only 92.5 percent of the benefits should be assigned to tower establishment. Thus, to calculate the benefits of tower establishment, B1, B2, and B3 calculated above are replaced by (0.925 x B1), (0.925 x B2), and (0.925 x B3). If a tower establishment candidate will operate less than 16 hours per day, the 92.5 percent should be adjusted to reflect the percentage of daily operations which will occur when the tower is open (by changing this value in the Critical Value File as discussed in Chapter IX).

On the other hand, all of the benefits calculated above are used for the discontinuance case, since towered airport operation counts already reflect only those hours when the tower is operating.

F. Total Annual Benefits

The total annual benefits, BT, of an airport traffic control tower is the sum of the benefits in the three categories above:

$$BT = B1 + B2 + B3$$

Using the TAF data, this benefit sum can be computed as discussed above for each year of the 15-year time-frame.

G. Total Lifetime Benefits

For each year j, in the 15-year time frame of our analysis, let BT(j) be the total annual benefit calculated above. The present value BPV of these BT(j)'s is calculated as follows:

$$BPV = \sum_{j=1}^{15} \frac{BT(j)}{(1.0 + DISC)^{j-0.5}}$$

where DISC is the discount rate expressed in fractional form. We use a 10 percent discount rate, i.e. DISC = 0.10, as prescribed by the Office of Management and Budget.[5]

5 The values for $\frac{1}{(1.0 + DISC)^{j-0.5}}$ for j = 1 thru 15 are provided in Table 8.6.

V. RESULTS AND IMPACT OF TOWER CRITERIA

While the tower criteria themselves are independent of any particular aviation forecast, establishment and discontinuance criteria results based upon one particular set of activity and forecasts are shown in this and subsequent chapters to help the reader to assess the impact of these criteria. These results are used to obtain an estimated number of tower candidates, compare old and new criteria, compare Phase I and benefit-cost criteria, and perform sensitivity analyses.

The tower criteria were applied to the 4303 airports in the latest version of the Terminal Area Forecast (TAF) file.[1] This TAF file contains reported activity data for 1980 and 1981 and forecast activity data for the years 1982 thru 1994. The results presented in the remainder of this report have been derived using this file and the "default"[2] critical values and costs developed in Chapters III and IV and Appendix A. When the criteria are applied to a particular location, site-specific costs and values and the most recent aviation activity and forecasts should be used.

Our discussion will focus on the Phase II benefit/cost (B/C) ratios. However, for the reader's convenience the computer generated results also show the Phase I criteria results and net present values. The Phase I results are discussed in the following chapter. The net-present values, benefits minus costs (B - C), indicate the actual monetary value of installing or discontinuing a tower. Net present value is a useful way to consider investment strategies. Since the computer programs were run using "default" values only, the ranking of sites by benefit/cost ratios and net present values is equivalent. However, this may no longer be true when site-specific values are substituted for such variables as costs or passenger counts.

A. Establishment Criteria Results

The establishment criteria were run for 3699 airports without towers in the TAF file. Activity data for non-towered airports is reported by the airport operator. Before the airport may become an FAA tower candidate, activity must be verified by three on-site traffic surveys. Fifty-nine

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1 As of October 18, 1982

2 "Default" value is standard computer terminology for the values used by the computer program if the user does not provide his own values. For example, unless the user inputs site-specific cost values, the national average values given in Chapter III are used by default.

airports have benefit/cost ratios greater than or equal to 0.50. The results for these airports are listed in Table 5.1 in order of decreasing benefit/cost ratios, B/C. The TCODE column is the tower code from the TAF file: TCODE = 0 means that the site has no tower, and TCODE = 7 means that the site is a tower candidate.

Table 5.1 shows that seventeen airports satisfy the Phase II criteria. One site has benefit/cost ratios greater than 2.0; in other words, the benefits from installing a tower would be more then double the costs (over the fifteen years). An additional fifteen sites have benefit/cost ratios greater than 1.1. Thus sixteen sites are tower establishment candidates. One more site has a ratio between 1.0 and 1.09 and four have ratios between 0.90 and 0.99. These five sites would be considered "borderline" candidates, and consideration as potential establishment candidates should be based on non-economic factors. For completeness, establishment criteria results for the 307 locations with benefit/cost ratios 0.25 and greater are shown by region, state and city in Appendix E.

B. Tower Discontinuance Results

The discontinuance criteria were run for the 432 FAA towers in the TAF file. The results for the 145 airports with benefit/cost ratios less than 2.00 are given in Table 5.2 in order of increasing benefit/cost, B/C, ratio. The tower code, TCODE, for FAA towered airports is 1. Because some of the assumptions and values used in the benefit/cost analysis refer specifically to lower activity VFR towers, the benefit/cost ratios generated for busier towers are not meaningful in absolute terms. They do, however, serve as a convenient way to rank tower benefits by site. For this reason, and for the sake of completeness, the results for all of the 432 towered airports are given in Appendix E.

The frequency distribution and cumulative frequency distribution of the benefit/cost ratios shown in Table 5.3 are a good way to summarize these results and compare them with previous criteria and sensitivity analysis results (Chapter VII). The table shows that there are fifty-five towers which satisfy the Phase II benefit/cost criteria for tower discontinuance. Forty of the towers have benefit/cost ratios below 0.90 and are therefore discontinuance candidates. The additional fifteen sites with ratios between 0.90 and 1.00 and the ten sites with benefit/cost ratios between 1.00 and 1.10 should be considered "borderline" and be evaluated further. For example, a borderline tower which requires expensive new equipment or renovation to continue operation, should have the equipment or renovation costs included in the benefit-cost analysis as additional investment costs. Non-economic factors may also indicate a decision for either discontinuance or continued operation in borderline cases.

C. Comparison with Previous Establishment Criteria

The benefit/cost ratios generated under the previous establishment criteria (Reference 4) are compared with the ratios generated by these

TABLE 5.1 (PAGE 1)

NEW ESTABLISHMENT CRITERIA RESULTS
SORTED BY BENEFIT/COST RATIO

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
39J	EVERGREEN	AL	ASO	0	2.43	2.87	5930.
HDO	HONDO	TX	ASW	0	1.77	1.94	2973.
BET	BETHEL	AK	AAL	7	1.35	1.92	2929.
FDR	FREDERICK	OK	ASW	0	1.71	1.87	2750.
HUM	HOUMA	LA	ASW	7	1.37	1.63	2005.
ILE	KILLEEN	TX	ASW	0	1.29	1.52	1638.
FFT	FRANKFORT	KY	ASO	0	1.36	1.44	1360.
N87	ROBBINSVILLE	NJ	AEA	0	1.40	1.42	1343.
L66	CORONA	CA	AWP	0	1.27	1.28	898.
T02	HOUSTON	TX	ASW	0	1.16	1.23	718.
PRC	PRESCOTT	AZ	AWP	0	0.97	1.22	697.
5KE	KETCHIKAN	AK	AAL	0	0.89	1.19	593.
F26	PLANO	TX	ASW	0	1.05	1.19	596.
3S2	AURORA	OR	ANM	0	1.15	1.19	588.
BLM	BELMAR-FARMINGDALE	NJ	AEA	0	1.14	1.12	375.
S50	AUBURN	WA	ANM	0	0.86	1.10	303.
GXY	GREELEY	CO	ANM	7	1.08	1.05	160.
FBK	FAIRBANKS/FT WAINWRIGH	AK	AAL	0	0.98	0.96	-117.
CKA	CHEROKEE	OK	ASW	0	0.96	0.94	-175.
FRN	ANCHORAGE/FT RICHARDSO	AK	AAL	0	0.95	0.93	-220.
SGR	HOUSTON	TX	ASW	0	0.98	0.93	-235.
S88	ARLINGTON	WA	ANM	0	0.75	0.84	-516.
HDH	MOKULEIA	HI	AWP	0	0.92	0.83	-530.
4AC	ALBUQUERQUE	NM	ASW	0	0.90	0.77	-714.
CMA	CAMARILLO	CA	AWP	0	0.93	0.77	-720.
UGN	WAUKEGAN	IL	AGL	0	0.92	0.76	-775.
OTH	NORTH BEND	OR	ANM	0	0.85	0.75	-801.
OTZ	KOTZEBUE	AK	AAL	7	0.69	0.74	-828.
1S0	PUYALLUP	WA	ANM	0	0.65	0.71	-915.
ETB	WEST BEND	WI	AGL	0	0.79	0.71	-917.
FPR	FORT PIERCE	FL	ASO	7	0.77	0.69	-984.
GLS	GALVESTON	TX	ASW	0	0.83	0.69	-988.
SBP	SAN LUIS OBISPO	CA	AWP	0	0.81	0.69	-974.
JBR	JONESBORO	AR	ASW	0	0.71	0.69	-989.
O56	NOVATO	CA	AWP	0	0.93	0.69	-970.
W10	MANASSAS	VA	AEA	0	0.57	0.65	-1102.
MDD	MIDLAND	TX	ASW	0	0.77	0.63	-1168.
MCG	MCGRATH	AK	AAL	0	0.66	0.61	-1237.
CPM	COMPTON	CA	AWP	0	0.72	0.61	-1229.
3WE	ST LOUIS	MO	ACE	0	0.54	0.58	-1329.
59S	VANCOUVER	WA	ANM	0	0.72	0.58	-1331.
LOT	ROMBOVILLE	IL	AGL	0	0.77	0.56	-1391.
N67	PHILADELPHIA	PA	AEA	0	0.64	0.55	-1428.
1N1	SHIRLEY	NY	AEA	0	0.77	0.55	-1441.
F67	GRAND PRAIRIE	TX	ASW	0	0.75	0.55	-1434.
VIS	VISALIA	CA	AWP	0	0.68	0.55	-1420.
APF	NAPLES	FL	ASO	0	0.59	0.54	-1467.
G08	MONONGAHELA	PA	AEA	0	0.73	0.53	-1489.
T29	PEARLAND	TX	ASW	0	0.62	0.53	-1498.
3R3	AUSTIN	TX	ASW	0	0.68	0.53	-1496.

TABLE 5.1 (PAGE 2)

NEW ESTABLISHMENT CRITERIA RESULTS
SORTED BY BENEFIT/COST RATIO

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
TUP	TUPELO	MS	ASO	0	0.56	0.53	-1503.
7MY	MOUNT HOLLY	NJ	AEA	0	0.71	0.52	-1523.
U42	SALT LAKE CITY	UT	ANM	0	0.60	0.52	-1519.
22G	LORAIN/ELYRIA/	OH	AGL	0	0.70	0.52	-1519.
CUB	COLUMBIA	SC	ASO	0	0.64	0.52	-1520.
FNL	FORT COLLINS/LOVELAND/	CO	ANM	0	0.63	0.52	-1520.
P37	GLENDALE	AZ	AWP	0	0.64	0.52	-1533.
K84	LEES SUMMIT	MO	ACE	0	0.39	0.51	-1543.
NPS	HONOLULU	HI	AWP	0	0.66	0.50	-1575.

TABLE 5.2 (PAGE 1)

NEW DISCONTINUANCE CRITERIA RESULTS
SORTED BY BENEFIT/COST RATIO

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
TNT	MIAMI	FL	ASO	1	0.33	0.16	-1508.
SSI	BRUNSWICK	GA	ASO	1	0.37	0.22	-1390.
VDZ	VALDEZ	AK	AAL	1	0.25	0.22	-1387.
PSE	PONCE	PR	ASO	1	0.38	0.30	-1250.
MAZ	MAYAGUEZ	PR	ASO	1	0.36	0.30	-1255.
LWB	LEWISBURG	WV	AEA	1	0.42	0.37	-1130.
TUT	PAGO PAGO	SP	AWP	1	0.44	0.42	-1042.
PBF	PINE BLUFF	AR	ASW	1	0.51	0.44	-1001.
BEH	BENTON HARBOR	MI	AGL	1	0.57	0.47	-943.
PVW	PLAINVIEW	TX	ASW	1	0.60	0.49	-909.
MVY	MARTHAS VINEYARD	MA	ANE	1	0.61	0.54	-831.
LEB	LEBANON	NH	ANE	1	0.94	0.56	-789.
ADM	ARDMORE	OK	ASW	1	0.69	0.56	-793.
HOB	HOBBS	NM	ASW	1	0.59	0.56	-791.
GBG	GALESBURG	IL	AGL	1	0.63	0.57	-769.
AHN	ATHENS	GA	ASO	1	0.72	0.59	-733.
HKY	HICKORY	NC	ASO	1	0.76	0.62	-684.
DNV	DANVILLE	IL	AGL	1	0.46	0.62	-672.
AKR	AKRON	OH	AGL	1	0.85	0.62	-678.
OWB	OWENSBORO	KY	ASO	1	0.68	0.63	-662.
AWM	WEST MEMPHIS	AR	ASW	1	0.68	0.63	-665.
PDT	PENDLETON	OR	ANM	1	0.74	0.63	-657.
DKX	KNOXVILLE	TN	ASO	1	0.72	0.64	-642.
PAH	PADUCAH	KY	ASO	1	0.65	0.66	-615.
SPA	SPARTANBURG	SC	ASO	1	0.71	0.66	-609.
VLD	VALDOSTA	GA	ASO	1	0.67	0.66	-608.
EWN	NEW BERN	NC	ASO	1	0.72	0.69	-552.
CGI	CAPE GIRARDEAU	MO	ACE	1	0.74	0.69	-563.
HOT	HOT SPRINGS	AR	ASW	1	0.74	0.70	-539.
MOT	MINOT	ND	AGL	1	0.74	0.72	-509.
LRD	LAREDO	TX	ASW	1	0.76	0.72	-492.
TXK	TEXARKANA	AR	ASW	1	0.91	0.74	-462.
FCH	FRESNO	CA	AWP	1	0.82	0.75	-444.
ESF	ALEXANDRIA	LA	ASW	1	0.76	0.77	-415.
HLG	WHEELING	WV	AEA	1	0.88	0.79	-376.
MYV	MARYSVILLE	CA	AWP	1	0.79	0.80	-361.
STJ	ST JOSEPH	MO	ACE	1	0.84	0.82	-325.
MWA	MARION	IL	AGL	1	0.91	0.83	-300.
CSM	CLINTON	OK	ASW	1	0.84	0.85	-275.
JXN	JACKSON	MI	AGL	1	1.10	0.87	-239.
ACT	WACO	TX	ASW	1	1.14	0.90	-180.
CRE	NORTH MYRTLE BEACH	SC	ASO	1	0.91	0.93	-126.
ISO	KINSTON	NC	ASO	1	0.93	0.94	-101.
MCN	MACON	GA	ASO	1	0.85	0.94	-116.
ALW	WALLA WALLA	WA	ANM	1	0.82	0.94	-115.
DBQ	DUBUQUE	IA	ACE	1	1.04	0.94	-100.
TOP	TOPEKA	KS	ACE	1	1.04	0.95	-87.
FLO	FLORENCE	SC	ASO	1	1.05	0.95	-84.
MGW	MORGANTOWN	WV	AEA	1	0.94	0.95	-89.
SAF	SANTA FE	NM	ASW	1	1.01	0.96	-69.

TABLE 5.2 (PAGE 2)

NEW DISCONTINUANCE CRITERIA RESULTS
SORTED BY BENEFIT/COST RATIO

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
CIC	CHICO	CA	AWP	1	0.98	0.96	-74.
BMG	BLOOMINGTON	IN	AGL	1	0.83	0.97	-53.
CGX	CHICAGO	IL	AGL	1	1.23	0.97	-54.
GLH	GREENVILLE	MS	ASO	1	0.90	0.98	-35.
KWA	KWAJALEIN/MARSHALL IS	SP	AWP	1	1.04	0.99	-21.
BPT	BEAUMONT/PORT ARTHUR	TX	ASW	1	1.84	1.01	12.
SPG	ST PETERSBURG	FL	ASO	1	1.20	1.02	31.
JLN	JOPLIN	MO	ACE	1	0.76	1.02	35.
WDG	ENID	OK	ASW	1	0.82	1.03	62.
IDA	IDAHO FALLS	ID	ANM	1	0.70	1.06	105.
CGF	CLEVELAND	OH	AGL	1	1.19	1.08	145.
CKB	CLARKSBURG	WV	AEA	1	0.98	1.08	135.
EYW	KEY WEST	FL	ASO	1	0.92	1.08	148.
EWB	NEW BEDFORD	MA	ANE	1	1.22	1.09	164.
TVL	SOUTH LAKE TAHOE	CA	AWP	1	1.00	1.09	154.
MCE	MERCED	CA	AWP	1	1.01	1.10	181.
TYR	TYLER	TX	ASW	1	1.21	1.11	202.
HRL	HARLINGEN	TX	ASW	1	1.24	1.13	235.
TTD	TROUTDALE	OR	ANM	1	1.28	1.13	231.
TWF	TWIN FALLS	ID	ANM	1	0.90	1.14	252.
HGR	HAGERSTOWN	MD	AEA	1	1.12	1.14	244.
DTN	SHREVEPORT	LA	ASW	1	1.13	1.15	265.
PIH	POCATELLO	ID	ANM	1	1.00	1.16	290.
ORH	WORCESTER	MA	ANE	1	1.28	1.17	298.
GRI	GRAND ISLAND	NE	ACE	1	1.06	1.17	304.
IPT	WILLIAMSPORT	PA	AEA	1	1.16	1.19	342.
ASE	ASPEN	CO	ANM	1	1.00	1.19	334.
LCH	LAKE CHARLES	LA	ASW	1	1.17	1.19	331.
SSF	SAN ANTONIO	TX	ASW	1	1.14	1.20	355.
MSO	MISSOULA	MT	ANM	1	1.08	1.21	372.
ARB	ANN ARBOR	MI	AGL	1	1.18	1.21	372.
CXY	HARRISBURG	PA	AEA	1	1.23	1.22	385.
SLN	SALINA	KS	ACE	1	1.00	1.22	392.
MFD	MANSFIELD	OH	AGL	1	1.21	1.23	415.
OGD	OGDEN	UT	ANM	1	1.17	1.24	437.
LHD	ANCHORAGE	AK	AAL	1	1.19	1.24	434.
CLL	COLLEGE STATION	TX	ASW	1	1.39	1.24	432.
FLG	FLAGSTAFF	AZ	AWP	1	1.01	1.24	434.
TCL	TUSCALOOSA	AL	ASO	1	1.11	1.25	440.
LWM	LAWRENCE	MA	ANE	1	1.92	1.26	465.
OJC	OLATHE	KS	ACE	1	1.29	1.26	466.
COU	COLUMBIA	MO	ACE	1	0.81	1.27	480.
ITH	ITHACA	NY	AEA	1	1.16	1.28	499.
FYV	FAYETTEVILLE	AR	ASW	1	1.17	1.30	541.
GGG	LONGVIEW	TX	ASW	1	1.36	1.31	555.
MKK	KAUNAKAKAI	HI	AWP	1	1.76	1.33	586.
GMU	GREENVILLE	SC	ASO	1	1.16	1.37	663.
OLM	OLYMPIA	WA	ANM	1	0.98	1.38	686.
ELM	ELMIRA	NY	AEA	1	1.23	1.38	685.
SMX	SANTA MARIA	CA	AWP	1	1.22	1.38	676.

TABLE 5.2 (PAGE 3)

NEW DISCONTINUANCE CRITERIA RESULTS
SORTED BY BENEFIT/COST RATIO

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
HUT	HUTCHINSON	KS	ACE	1	1.26	1.39	690.
HKS	JACKSON	MS	ASO	1	1.25	1.40	711.
LMT	KLAMATH FALLS	OR	ANM	1	1.14	1.40	716.
MIE	MUNCIE	IN	AGL	1	1.03	1.41	739.
MKG	MUSKEGON	MI	AGL	1	1.19	1.43	766.
BGM	BINGHAMTON	NY	AEA	1	1.34	1.44	782.
AKN	KING SALMON	AK	AAL	1	1.19	1.46	826.
ALN	ALTON	IL	AGL	1	1.47	1.46	827.
SFF	SPOKANE	WA	ANM	1	1.31	1.47	839.
BTL	BATTLE CREEK	MI	AGL	1	1.25	1.49	884.
TIW	TACOMA	WA	ANM	1	1.22	1.50	891.
IPL	IMPERIAL	CA	AWP	1	1.31	1.50	898.
MWC	MILWAUKEE	WI	AGL	1	1.40	1.51	919.
ERI	ERIE	PA	AEA	1	1.24	1.53	951.
PKB	PARKERSBURG	WV	AEA	1	1.47	1.55	992.
LSE	LA CROSSE	WI	AGL	1	1.35	1.56	999.
RDD	REDDING	CA	AWP	1	1.32	1.58	1035.
ADQ	KODIAK	AK	AAL	1	1.33	1.60	1073.
LWS	LEWISTON	ID	ANM	1	1.08	1.63	1121.
ABI	ABILENE	TX	ASW	1	1.68	1.63	1131.
LAW	LAWTON	OK	ASW	1	1.32	1.65	1157.
FMN	FARMINGTON	NM	ASW	1	1.36	1.65	1164.
MEI	MERIDIAN	MS	ASO	1	1.47	1.68	1208.
CSG	COLUMBUS	GA	ASO	1	1.33	1.70	1246.
FMH	FALMOUTH	MA	ANE	1	1.64	1.70	1252.
BRO	BROWNSVILLE	TX	ASW	1	1.37	1.71	1269.
SNS	SALINAS	CA	AWP	1	1.46	1.72	1282.
SIG	SAN JUAN	PR	ASO	1	1.48	1.73	1309.
KCK	KANSAS CITY	KS	ACE	1	1.25	1.73	1303.
CHO	CHARLOTTESVILLE	VA	AEA	1	1.31	1.74	1327.
HLN	HELENA	MT	ANM	1	1.54	1.76	1351.
BVY	BEVERLY	MA	ANE	1	1.61	1.77	1382.
ARR	AURORA	IL	AGL	1	1.57	1.79	1419.
MFE	MC ALLEN	TX	ASW	1	1.42	1.81	1455.
CPS	EAST ST LOUIS	IL	AGL	1	1.89	1.83	1479.
MBS	SAGINAW	MI	AGL	1	1.63	1.84	1500.
BMI	BLOOMINGTON-NORMAL	IL	AGL	1	1.02	1.85	1517.
HTS	HUNTINGTON	WV	AEA	1	1.38	1.85	1520.
INT	WINSTON SALEM	NC	ASO	1	1.36	1.85	1525.
DXR	DANBURY	CT	ANE	1	1.68	1.87	1552.
WJF	LANCASTER	CA	AWP	1	1.56	1.88	1570.
JVL	JANESVILLE	WI	AGL	1	1.80	1.92	1649.
ACK	NANTUCKET	MA	ANE	1	1.99	1.93	1671.
ENA	KENAI	AK	AAL	1	1.41	1.98	1747.
LYH	LYNCHBURG	VA	AEA	1	1.41	1.99	1780.

Table 5.3

Benefit/Cost Ratio Distributions
For New Discontinuance Criteria

Interval		Frequency	Cumulative Frequency
Below	0.10	0	0
0.10	0.19	1	1
0.20	0.29	2	3
0.30	0.39	3	6
0.40	0.49	4	10
0.50	0.59	6	16
0.60	0.69	12	28
0.70	0.79	7	35
0.80	0.89	5	40
0.90	0.99	15	55
1.00	1.09	10	65
1.10	1.19	13	78
1.20	1.29	15	93
1.30	1.39	8	101
1.40	1.49	9	110
1.50	1.59	7	117
1.60	1.69	6	123
1.70	1.79	10	133
1.80	1.89	8	141
1.90	1.99	4	145
2.00 and above		287	432

criteria in Table 5.4. All sites with benefit/cost ratios greater than or equal to 0.90 under either the new or old establishment criteria are shown in the table. The benefit/cost ratios for the new criteria were developed using reported 1980 and 1981 activity and forecast activity for 1982-1994. The benefit/cost ratios for the old criteria use only the 1980 data, because the criteria for tower establishment now in effect compare one year's benefits with annual costs plus annual capital recovery costs for site-preparation and construction (Reference 4).

These results are summarized in Table 5.5. It is clear from both tables that more sites qualify for establishment under the previous criteria then under these. As shown in the tables there are twenty-five candidates (B/C $\geq$ 1.00) under the old criteria, compared with seventeen under these criteria, a difference of eight candidates. With B/C $\geq$ 0.90 are thirty-four under the old compared with twenty-one under these. All sites but one which qualify for establishment under new criteria qualified under old criteria. The one site, Auburn, WA, has very strong growth in activity forecasted. As shown in the table, nine sites which formerly qualified no longer meet establishment criteria. The column of Table 5.3 labeled CHG is the actual change in the B/C ratio; the column labeled %CHG is the percentage change in the B/C ratio: new minus old

TABLE 5.4 (PAGE 1)

COMPARISON OF NEW AND OLD ESTABLISHMENT CRITERIA

LOC ID	CITY	ST	REG	TCODE	BENEFITS/COSTS NEW	OLD	CHG	%CHG	MEET CRITERIA? NEW	OLD
FRN	ANCHORAGE/FT RICHARDSO	AK	AAL	0	0.93	1.27	-0.34	-25.	NO	YES
BET	BETHEL	AK	AAL	7	1.92	2.81	-0.89	-22.	YES	YES
BIG	DELTA JUNCTION/FT GREE	AK	AAL	0	0.40	0.93	-0.53	-56.	NO	NO
FBK	FAIRBANKS/FT WAINWRIGH	AK	AAL	0	0.96	1.53	-0.57	-37.	NO	YES
5KE	KETCHIKAN	AK	AAL	0	1.19	1.56	-0.37	-14.	YES	YES
OTZ	KOTZEBUE	AK	AAL	7	0.74	1.34	-0.60	-34.	NO	YES
OME	NOME	AK	AAL	0	0.41	0.97	-0.56	-46.	NO	NO
BLM	BELMAR-FARMINGDALE	NJ	AEA	0	1.12	1.44	-0.32	-19.	YES	YES
N87	ROBBINSVILLE	NJ	AEA	0	1.42	1.44	-0.02	-1.	YES	YES
UGN	WAUKEGAN	IL	AGL	0	0.76	0.96	-0.20	-18.	NO	NO
4D0	GRAND LEDGE	MI	AGL	0	0.48	0.93	-0.45	-48.	NO	NO
ETB	WEST BEND	WI	AGL	0	0.71	1.01	-0.30	-28.	NO	YES
AUG	AUGUSTA	ME	ANE	0	0.30	1.07	-0.77	-104.	NO	YES
GXY	GREELEY	CO	ANM	7	1.05	1.06	-0.01	-1.	YES	YES
3S2	AURORA	OR	ANM	0	1.19	1.17	0.02	1.	YES	YES
OTH	NORTH BEND	OR	ANM	0	0.75	1.22	-0.47	-36.	NO	YES
SGU	ST. GEORGE	UT	ANM	0	0.44	0.95	-0.51	-44.	NO	NO
S50	AUBURN	WA	ANM	0	1.10	0.86	0.24	16.	YES	NO
39J	EVERGREEN	AL	ASO	0	2.87	3.44	-0.57	-16.	YES	YES
FFT	FRANKFORT	KY	ASO	0	1.44	1.84	-0.40	-21.	YES	YES
TUP	TUPELO	MS	ASO	0	0.53	0.93	-0.40	-38.	NO	NO
HUM	HOUMA	LA	ASW	7	1.63	1.71	-0.08	-3.	YES	YES
CKA	CHEROKEE	OK	ASW	0	0.94	1.54	-0.60	-38.	NO	YES
FDR	FREDERICK	OK	ASW	0	1.87	2.38	-0.51	-21.	YES	YES
GLS	GALVESTON	TX	ASW	0	0.69	0.98	-0.29	-24.	NO	NO
HDO	HONDO	TX	ASW	0	1.94	2.54	-0.60	-23.	YES	YES
SGR	HOUSTON	TX	ASW	0	0.93	0.96	-0.03	-2.	NO	NO
T02	HOUSTON	TX	ASW	0	1.23	1.21	0.02	1.	YES	YES
ILE	KILLEEN	TX	ASW	0	1.52	1.65	-0.13	-5.	YES	YES
F26	PLANO	TX	ASW	0	1.19	1.40	-0.21	-10.	YES	YES
PRC	PRESCOTT	AZ	AWP	0	1.22	1.15	0.07	4.	YES	YES
L66	CORONA	CA	AWP	0	1.28	1.28	0.0	0.	YES	YES
O56	NOVATO	CA	AWP	0	0.69	1.06	-0.37	-31.	NO	YES
SBP	SAN LUIS OBISPO	CA	AWP	0	0.69	0.94	-0.25	-22.	NO	NO
HDH	MOKULEIA	HI	AWP	0	0.83	1.03	-0.20	-17.	NO	YES

Table 5.5

Benefit/Cost Ratio Distributions for New and Old Establishment Criteria

Interval	Frequency New	Frequency Old	Cumulative Frequency New	Cumulative Frequency Old
1.10 and above	16	20	16	20
1.00 to 1.09	1	5	17	25
0.90 to 0.99	4	9	21	34

divided by old. All of the sites listed, except for Auburn, now have ratio values which are lower or approximately the same as under the previous criteria. Thus the new establishment criteria are somewhat more stringent than the old and are influenced by forecast as well as present activity.

D. Comparison with Previous Discontinuance Criteria

The frequency and cumulative frequency distributions of the benefit/cost ratios derived from the previous discontinuance criteria (Reference 5) and these new criteria are shown in Table 5.6. Both new and old discontinuance criteria use reported 1980 and 1981 activity and forecast activity for 1982-1994. By comparing the cumulative frequency distributions, one can see that while there are more discontinuance candidates under the new criteria than under the old, there are the same number of sites with B/C $<$ 1.50, and more sites with B/C $<$ 2.00 under the old than under the new. The table shows forty-two candidates for discontinuance under old criteria, compared with fifty-five under the new--a difference of thirteen locations--twenty-six sites have B/C $<$ 0.90 under the old compared with forty under the new.

Table 5.7 compares the old and new criteria for all locations with either new or old B/C $<$ 1.10. Of the fifty-five sites which are discontinuance candidates under the new criteria, thirty-nine were also candidates for discontinuance under the old criteria and sixteen were not. Of these sixteen sites, eleven are "borderline" under the new criteria, with 0.90 $\leq$ B/C $<$ 1.00. The five sites with B/C ratios below 0.90 are:

PAH Paducah KY with new B/C ratio = 0.66
and old B/C ratio = 1.11

EWN New Bern NC with new B/C ratio = 0.69
and old B/C ratio = 1.00

Table 5.6

Benefit/Cost Ratio Distributions
For New and Old Discontinuance Criteria

Interval		Frequency New	Frequency Old	Cumulative Frequency New	Cumulative Frequency Old
Below	0.10	0	0	0	0
0.10	0.19	1	0	1	0
0.20	0.29	2	0	3	0
0.30	0.39	3	1	6	1
0.40	0.49	4	1	10	2
0.50	0.59	6	0	16	2
0.60	0.69	12	6	28	8
0.70	0.79	7	5	35	13
0.80	0.89	5	13	40	26
0.90	0.99	15	16	55	42
1.00	1.09	10	11	65	53
1.10	1.19	13	10	78	63
1.20	1.29	15	18	93	81
1.30	1.39	8	16	101	97
1.40	1.49	9	7	110	104
1.50	1.59	7	13	117	117
1.60	1.69	6	12	123	129
1.70	1.79	10	8	133	137
1.80	1.89	8	12	141	149
1.90	1.99	4	12	145	161
2.00 and above		287	271	432	432

**ESF Alexandria LA with new B/C ratio = 0.77
and old B/C ratio = 1.13**

**CSM Clinton OK with new B/C ratio = 0.85
and old B/C ratio = 1.22**

**TUT Pago Pago SP with new B/C ratio = 0.42
and old B/C ratio = 1.05**

An additional three sites which qualified for discontinuance under the old criteria no longer qualify under the new. However, the B/C ratios under the old criteria for these three sites were all larger than 0.90. Thus, except for the five sites specified above, the benefit/cost ratios under the new and old criteria are similar, although the new criteria are somewhat more stringent than the old.

Sensitivity studies showing how various assumptions affect the results presented in this Chapter are given in Chapter VII.

TABLE 5.7 (PAGE 1)

COMPARISON OF NEW AND OLD DISCONTINUANCE CRITERIA

LOC ID	CITY	ST	REG	TCODE	BENEFITS/COSTS NEW	OLD	CHG	%CHG	MEET CRITERIA? NEW	OLD
VDZ	VALDEZ	AK	AAL	1	0.22	0.91	-0.69	-76.	YES	YES
DBQ	DUBUQUE	IA	ACE	1	0.94	1.09	-0.15	-14.	YES	NO
OJC	OLATHE	KS	ACE	1	1.26	1.04	0.22	21.	NO	NO
TOP	TOPEKA	KS	ACE	1	0.95	0.91	0.04	4.	YES	YES
CGI	CAPE GIRARDEAU	MO	ACE	1	0.69	0.89	-0.20	-22.	YES	YES
JLN	JOPLIN	MO	ACE	1	1.02	1.28	-0.26	-20.	NO	NO
STJ	ST JOSEPH	MO	ACE	1	0.82	0.95	-0.13	-14.	YES	YES
CXY	HARRISBURG	PA	AEA	1	1.22	1.08	0.14	13.	NO	NO
CKB	CLARKSBURG	WV	AEA	1	1.08	1.38	-0.30	-22.	NO	NO
LWB	LEWISBURG	WV	AEA	1	0.37	0.70	-0.33	-47.	YES	YES
MGW	MORGANTOWN	WV	AEA	1	0.95	1.24	-0.29	-23.	YES	NO
HLG	WHEELING	WV	AEA	1	0.79	0.97	-0.18	-19.	YES	YES
CGX	CHICAGO	IL	AGL	1	0.97	0.99	-0.02	-2.	YES	YES
DNV	DANVILLE	IL	AGL	1	0.62	0.93	-0.31	-33.	YES	YES
GBG	GALESBURG	IL	AGL	1	0.57	0.85	-0.28	-33.	YES	YES
MWA	MARION	IL	AGL	1	0.83	0.97	-0.14	-14.	YES	YES
BMG	BLOOMINGTON	IN	AGL	1	0.97	1.22	-0.25	-20.	YES	NO
ARB	ANN ARBOR	MI	AGL	1	1.21	1.03	0.18	17.	NO	NO
BEH	BENTON HARBOR	MI	AGL	1	0.47	0.70	-0.23	-33.	YES	YES
JXN	JACKSON	MI	AGL	1	0.87	0.91	-0.04	-4.	YES	YES
MOT	MINOT	ND	AGL	1	0.72	0.91	-0.19	-21.	YES	YES
AKR	AKRON	OH	AGL	1	0.62	0.67	-0.05	-7.	YES	YES
CGF	CLEVELAND	OH	AGL	1	1.08	0.95	0.13	14.	NO	YES
LWM	LAWRENCE	MA	ANE	1	1.26	1.09	0.17	16.	NO	NO
MVY	MARTHAS VINEYARD	MA	ANE	1	0.54	0.88	-0.34	-39.	YES	YES
EWB	NEW BEDFORD	MA	ANE	1	1.09	1.25	-0.16	-13.	NO	NO
LEB	LEBANON	NH	ANE	1	0.56	0.79	-0.23	-29.	YES	YES
IDA	IDAHO FALLS	ID	ANM	1	1.06	1.40	-0.34	-24.	NO	NO
PDT	PENDLETON	OR	ANM	1	0.63	0.88	-0.25	-28.	YES	YES
TTD	TROUTDALE	OR	ANM	1	1.13	1.05	0.08	8.	NO	NO
OGD	OGDEN	UT	ANM	1	1.24	1.05	0.19	18.	NO	NO
ALW	WALLA WALLA	WA	ANM	1	0.94	1.12	-0.18	-16.	YES	NO
EYW	KEY WEST	FL	ASO	1	1.08	1.30	-0.22	-17.	NO	NO
TNT	MIAMI	FL	ASO	1	0.16	0.35	-0.19	-54.	YES	YES
SPG	ST PETERSBURG	FL	ASO	1	1.02	0.94	0.08	9.	NO	YES
AHN	ATHENS	GA	ASO	1	0.59	0.71	-0.12	-17.	YES	YES
SSI	BRUNSWICK	GA	ASO	1	0.22	0.40	-0.18	-45.	YES	YES
MCN	MACON	GA	ASO	1	0.94	1.18	-0.24	-20.	YES	NO
VLD	VALDOSTA	GA	ASO	1	0.66	0.83	-0.17	-20.	YES	YES
OWB	OWENSBORO	KY	ASO	1	0.63	0.81	-0.18	-22.	YES	YES
PAH	PADUCAH	KY	ASO	1	0.66	1.11	-0.45	-41.	YES	NO
GLH	GREENVILLE	MS	ASO	1	0.98	1.27	-0.29	-23.	YES	NO
HKY	HICKORY	NC	ASO	1	0.62	0.89	-0.27	-30.	YES	YES
ISO	KINSTON	NC	ASO	1	0.94	1.28	-0.34	-27.	YES	NO
EWN	NEW BERN	NC	ASO	1	0.69	1.00	-0.31	-31.	YES	NO

TABLE 5.7 (PAGE 2)

COMPARISON OF NEW AND OLD DISCONTINUANCE CRITERIA

LOC ID	CITY	ST	REG	TCODE	BENEFITS/COSTS NEW	OLD	CHG	%CHG	MEET CRITERIA? NEW	OLD
MAZ	MAYAGUEZ	PR	ASO	1	0.30	0.87	-0.57	-66.	YES	YES
PSE	PONCE	PR	ASO	1	0.30	0.83	-0.53	-64.	YES	YES
FLO	FLORENCE	SC	ASO	1	0.95	1.22	-0.27	-22.	YES	NO
CRE	NORTH MYRTLE BEACH	SC	ASO	1	0.93	0.89	0.04	4.	YES	YES
SPA	SPARTANBURG	SC	ASO	1	0.66	0.75	-0.09	-12.	YES	YES
DKX	KNOXVILLE	TN	ASO	1	0.64	0.68	-0.04	-6.	YES	YES
HOT	HOT SPRINGS	AR	ASW	1	0.70	0.92	-0.22	-24.	YES	YES
PBF	PINE BLUFF	AR	ASW	1	0.44	0.60	-0.16	-27.	YES	YES
TXK	TEXARKANA	AR	ASW	1	0.74	0.99	-0.25	-25.	YES	YES
AWM	WEST MEMPHIS	AR	ASW	1	0.63	0.67	-0.04	-6.	YES	YES
ESF	ALEXANDRIA	LA	ASW	1	0.77	1.13	-0.36	-32.	YES	NO
DTN	SHREVEPORT	LA	ASW	1	1.15	0.98	0.17	17.	NO	YES
HOB	HOBBS	NM	ASW	1	0.56	0.82	-0.26	-32.	YES	YES
SAF	SANTA FE	NM	ASW	1	0.96	0.98	-0.02	-2.	YES	YES
ADM	ARDMORE	OK	ASW	1	0.56	0.63	-0.07	-11.	YES	YES
CSM	CLINTON	OK	ASW	1	0.85	1.22	-0.37	-30.	YES	NO
WDG	ENID	OK	ASW	1	1.03	1.17	-0.14	-12.	NO	NO
BPT	BEAUMONT/PORT ARTHUR	TX	ASW	1	1.01	1.35	-0.34	-25.	NO	NO
LRD	LAREDO	TX	ASW	1	0.72	0.96	-0.24	-25.	YES	YES
PVW	PLAINVIEW	TX	ASW	1	0.49	0.66	-0.17	-26.	YES	YES
SSF	SAN ANTONIO	TX	ASW	1	1.20	1.05	0.15	14.	NO	NO
ACT	WACO	TX	ASW	1	0.90	1.15	-0.25	-22.	YES	NO
CIC	CHICO	CA	AWP	1	0.96	1.04	-0.08	-8.	YES	NO
FCH	FRESNO	CA	AWP	1	0.75	0.81	-0.06	-7.	YES	YES
MYV	MARYSVILLE	CA	AWP	1	0.80	0.82	-0.02	-2.	YES	YES
TVL	SOUTH LAKE TAHOE	CA	AWP	1	1.09	1.35	-0.26	-19.	NO	NO
KWA	KWAJALEIN/MARSHALL IS	SP	AWP	1	0.99	1.26	-0.27	-21.	YES	NO
TUT	PAGO PAGO	SP	AWP	1	0.42	1.05	-0.63	-60.	YES	NO

VI. SIMPLE PHASE I CRITERIA

Phase I criteria are simple "rules of thumb" designed to identify potential candidates for tower establishment and discontinuance. Unlike Phase II benefit/cost criteria, they are easily applied with available data and without the aid of a computer. Under Phase I, a ratio value is computed for each aircraft class by dividing the number of operations at the airport for that aircraft class by the number of operations which would qualify an airport for a tower if it had operations in only that class increasing at the national average growth rate. The ratios for all aircraft classes are summed to obtain the Phase I Ratio Sum.

Two different ratio sums are used for tower criteria--one for establishment and one for discontinuance.[1] If the Phase I Establishment Ratio Sum

$$\frac{AC}{38{,}000} + \frac{AT}{90{,}000} + \frac{GAI}{160{,}000} + \frac{GAL}{280{,}000} + \frac{MI}{48{,}000} + \frac{ML}{90{,}000}$$

is greater than or equal to one, the airport becomes an establishment candidate. If the Phase I Discontinuance Ratio Sum

$$\frac{AC}{15{,}000} + \frac{AT}{40{,}000} + \frac{GAI}{75{,}000} + \frac{GAL}{125{,}000} + \frac{MI}{20{,}000} + \frac{ML}{35{,}000}$$

drops below one, the location becomes a discontinuance candidate. The demoninators for the discontinuance sum are smaller, because fewer operations are required to continue to operate an existing tower than to establish a new one. The Phase I criteria results are shown in Tables 5.1 and 5.2.

Phase I criteria are published in Airway Standard Number One because they provide a useful screening tool as well as easily understood approximate, measures of activity levels which qualify locations for tower establishment or discontinuance.

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1 This is a departure from current practice which uses the same ratio sum for discontinuance as for establishment, but requires that the sum be smaller than some constant value which is much less than 1.0 and varies among the various criteria. (See Reference 1 for examples.) For towers, better agreement between the two phases was obtained by developing a different ratio sum for discontinuance.

A. Development of Phase I Criteria

To develop the Phase I ratio sums, for each aircraft class, we assumed that some hypothetical airport's activity consists of only this class operations and furthermore that activity is increasing at the national average growth rate for this class obtained from the TAF file. Then the number of operations which just brings the benefit/cost ratio to 1.0 becomes the denominator for that class. Figure 6.1 shows the relationship between Phase I and Phase II establishment values for a hypothetical airport with only general aviation itinerant activity.

B. Reasons for Disagreement between Phases

There are two reasons why the two criteria phases may not agree.

The primary reason is related to activity growth. One feature of these criteria not in previous ones is using site-specific activity forecasts. In this way greater or slower than average growth rates anticipated for particular regions or even particular airports, which have been incorporated into the TAF file, are automatically incorporated into the benefit/cost analysis. It is not possible for one test, such as the Phase I Ratio Sum, based on only one year's activity, to reflect these varying growth rates. Furthermore, the Phase I test was developed using the average growth rates for the TAF file. These growth rates which are based on economic forecasts may change over time. As they do change, the correspondence between Phase I and Phase II will deteriorate. The "match" will become even worse if activity growth increases for some aircraft classes while declining for others. Table 6.1 compares the two phases under the new and old criteria. The table shows a much better match between the two phases for the new criteria. One reason for this is changes in the growth rates since the previous criteria were developed.

Table 6.1

Comparison of Phase I and Phase II Criteria

Establishment	New Criteria	Old Criteria
Meet both Phase II and Phase I	14	15
Meet Phase II but not Phase I	3	10
Meet Phase I but not Phase II	0	21
Discontinuance		
Meet both Phase II and Phase I	47	40
Meet Phase II but not Phase I	8	2
Meet Phase I but not Phase II	8	37

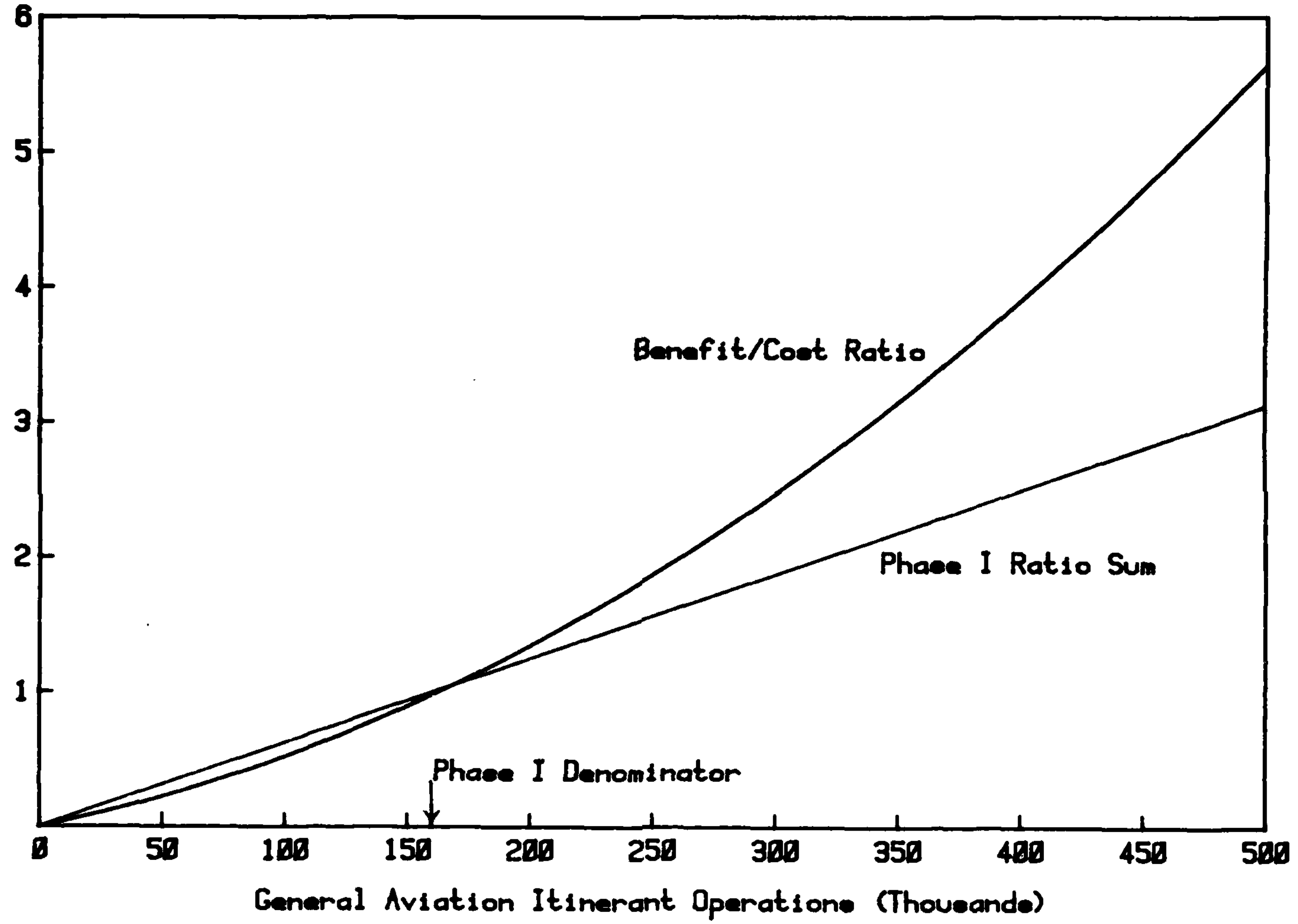


Figure 6.1 Relationship between Phase I and Phase II Establishment Results for Hypothetical Location with only General Aviation Itinerant Activity

Another reason why the two phases may not match is a mathematical one, illustrated by Figure 6.1. If the functional relationship between activity and tower benefits were linear, as it is for some criteria, then a simple linear function like the Phase I sum may match the benefit/cost ratio very well. However, since this relationship is a combination of both linear functions of activity, for B2 and B3, and quadratic functions of activity for B1, it is not possible to match the entire curve with a simple linear function. It is, however, possible to get a good linear (straight line) approximation for each aircraft class in some small interval. Therefore, we match the Phase I straight line with the Phase II curve in an interval centered about the point where the benefit/cost ratio is one. Thus the two phases will match very well near one, but the further the ratios are from one, the further apart they will become. This phenomenon can be seen in Figure 6.1 and also by comparing the results from both phases for some of the busier airports in Table F.2.

C. Comparing Results of the Two Phases

1. Establishment

Of approximately thirty-seven hundred locations run through the new establishment criteria there are only four locations where the Phase I and Phase II criteria yield different decisions. All sites which meet Phase I criteria also meet Phase II criteria. Three locations:

5KE Ketchikan AK with Phase I Sum = 0.89
Benefit/Cost Ratio = 1.19

PRC Prescott AZ with Phase I Sum = 0.97
Benefit/Cost Ratio = 1.22

S50 Auburn OK with Phase I Sum = 0.86
Benefit/Cost Ratio = 1.10

were not identified by the Phase I test in spite of favorable benefit/cost ratios, because their forecast activity growth is much greater than average. These latter three cases are good illustrations of the need to use the benefit/cost ratio when the two phases are not in agreement.

2. Discontinuance

Table 6.2 shows sixteen locations where Phase I and Phase II discontinuance criteria do not agree. Eight sites meet the first phase, but not the second phase. All of these locations have faster than average growth forecasted. For example, the average forecast growth in total operations is 8.7 percent for Joplin, MO, 8.2 percent for Columbia, MO, 6.3 percent for Olympia, WN, 6.0 percent for Idaho Falls, ID, 5.0 percent for Twin Falls, ID, and 4.7 percent for Enid, OK, compared with national average growth of about 3.6 percent for towered airports. Two locations, Clarksburg, WV, and Key West, FL, are "borderline" in both phases.

Table 6.2

Locations with Different Discontinuance Criteria Results for Two Phases

LOC ID	City	ST	REG	TCODE	Phase I	B/C	B-C ($K)
JXN	JACKSON	MI	AGL	1	1.10	0.87	-239.
ACT	WACO	TX	ASW	1	1.14	0.90	-180.
DBQ	DUBUQUE	IA	ACE	1	1.04	0.94	-100.
TOP	TOPEKA	KS	ACE	1	1.04	0.95	-87.
FLO	FLORENCE	SC	ASO	1	1.05	0.95	-84.
SAF	SANTA FE	NM	ASW	1	1.01	0.96	-69.
CGX	CHICAGO	IL	AGL	1	1.23	0.97	-54.
KWA	KWAJALEIN/MARSHALL IS	SP	AWP	1	1.04	0.99	-21.
JLN	JOPLIN	MO	ACE	1	0.76	1.02	35.
WDG	ENID	OK	ASW	1	0.82	1.03	62.
IDA	IDAHO FALLS	ID	ANM	1	0.70	1.06	105.
CKB	CLARKSBURG	WV	AEA	1	0.98	1.08	135.
EYW	KEY WEST	FL	ASO	1	0.92	1.08	148.
TWF	TWIN FALLS	ID	ANM	1	0.90	1.14	252.
OLM	OLYMPIA	WA	ANM	1	0.98	1.38	686.
COU	COLUMBIA	MO	ACE	1	0.81	1.27	480.

Eight sites meet the second phase but not the first. Five are "borderline" in both phases--Dubuque, IA, Topeka, KS, Florence, SC, Santa Fe, NM and Kwajalein/Marshall Is, SP. Of the other three sites, Waco, TX, and Chicago (Meigs), IL, have growth rates of only 2.2 percent and 1.7 percent, respectively, while Jackson, MI, has a shift from air carrier to air taxi operations forecasted.

VII. SENSITIVITY ANALYSIS

The new tower criteria results depend upon many assumptions. This Chapter examines the sensitivity of the benefit/cost (Phase II) results to several key assumptions.

A. Changes in Critical Values and Costs

All of the critical values and costs used to develop these criteria were updated from earlier values. A natural question is what impact these changes have had on the criteria results. One way to demonstrate the impact of these changes is to run the new criteria algorithm using the

Table 7.1

Distributions For New Discontinuance Criteria vs. Sensitivity Study Using Old Critical Values and Costs in New Algorithm

Interval		Frequency New	Frequency Sen	Cumulative Frequency New	Cumulative Frequency Sen
Below	0.10	0	0	0	0
0.10	0.19	1	2	1	2
0.20	0.29	2	1	3	3
0.30	0.39	3	4	6	7
0.40	0.49	4	5	10	12
0.50	0.59	6	10	16	22
0.60	0.69	12	12	28	34
0.70	0.79	7	9	35	43
0.80	0.89	5	8	40	51
0.90	0.99	15	9	55	60
1.00	1.09	10	10	65	70
1.10	1.19	13	9	78	79
1.20	1.29	15	11	93	90
1.30	1.39	8	6	101	96
1.40	1.49	9	4	110	100
1.50	1.59	7	13	117	113
1.60	1.69	6	9	123	122
1.70	1.79	10	9	133	131
1.80	1.89	8	7	141	138
1.90	1.99	4	5	145	143
2.00	and above	287	289	432	432

old critical values and costs. The results of doing this are compared with the results using the new critical values and costs in Table 7.1. Using the old values produces sixty discontinuance candidates compared with fifty-five using the new values. Thus updating the values has not had much impact on these criteria, although they are somewhat less severe. On the other hand, changing the algorithm has had the opposite effect. The diagonal of the matrix in Table 7.2 (55, 42) synthesizes the impact of changing both the algorithm and the critical values/costs. The net effect is slightly more stringent discontinuance criteria.

Table 7.2

Number of Discontinuance Candidates Using Old Critical Values and Costs in New Algorithm vs. New Critical Values and Cost in Old Algorithm

Critical Values and Costs	Algorithm New	Algorithm Old
New	55	24
Old	60	42

Similar effects are reflected in the establishment criteria. The new critical values and costs tend to increase the number of candidates, while the algorithm change tends to decrease the number. The net effect, however, is a more restrictive establishment criteria (see Table 7.3).

Table 7.3

Number of Establishment Candidates Using Old Critical Values and Costs in New Algorithm vs. New Critical Values and Costs in Old Algorithm

Critical Values and Costs	Algorithm New	Algorithm Old
New	17	44
Old	17	25

Because the air carrier aircraft which land at the type of airport which is a potential candidate for tower establishment or discontinuance tend to be smaller, on the average, than the entire fleet of air carrier aircraft, the critical values used for air-carriers in the new criteria have been calculated from a special distribution as discussed in Appendix A.

The impact of using the national average values instead of these calculated values in the new tower discontinuance criteria algorithm was assessed. It was found that the number of discontinuance candidates dropped from fifty-five to forty-five; in other words ten sites would no longer qualify for tower discontinuance if national average values for air carriers were used.[1]

B. Changes in Approach from Previous Criteria

Several changes in approach from previous criteria were made. One important change is using "expected values" for safety benefits in establishment criteria and confidence interval "upper bounds" in discontinuance criteria as discussed in Sections 5A and 5B. Old criteria, for both establishment and discontinuance, used expected values multiplied by a "safety factor" to account for inherent uncertainties in the data used to derive these benefits.

Table 7.4 shows the impact of this change on tower establishment criteria. The new establishment algorithm was run using three different accident and collision functions to calculate safety benefits B1 and B2: mean values functions, mean value functions multiplied by a "safety factor" of two, and confidence interval upper bounds for these functions. The old establishment algorithm was run with and without the "safety factor." The numbers of establishment candidates which resulted are also shown in the table.

Table 7.4

Number of Establishment Candidates Using Mean Values, Upper Bounds, and Safety Factors in New and Old Criteria

Accident and Collision Functions	Algorithm	
	New	Old
Mean Values	17	5
2 x Mean Values	30	25
Upper Bounds	38	-

1 Critical values, which reflect the particular mix of aircraft at a location, may be used when running the criteria for that site only, as discussed in Chapter IX.

Table 7.5 shows analogus results for discontinuance criteria.

Table 7.5

Number of Discontinuance Candidates Using Mean Values, Upper Bounds, and Safety Factors in New and Old Criteria

Accident and Collision Functions	Algorithm New	Algorithm Old
Mean Values	97	138
2 x Mean Values	60	42
Upper Bounds	55	-

In both cases--establishment and discontinuance--the criteria are much more stringent when mean values are used instead of an upper bound or safety factor approach. The "upper bound" approach results in even less stringent criteria than using the safety factor of two.

The second major change in approach is related to the assignment of a certain percentage of the total benefits to account for "other" benefits which were considered "nonquantifiable." These benefits are discussed in Section 4.D. Previous criteria assigned an additional twenty percent to account for these benefits. The impact on the discontinuance results of continuing this practice is shown in Table 7.6. Notice that even allowing only this twenty percent for other benefits has a noticeable impact, decreasing the number of discontinuance candidates from fifty-five to thirty-seven. The table shows that the impact of adding a percentage for other benefits is about the same on both the new and old algorithm.

Table 7.6

Number of Discontinuance Candidates Using Twenty Percent for Other Benefits in New Algorithm vs. Using Zero Percent for Other Benefits in Old Algorithm

Value for Other Benefits	Algorithm New	Algorithm Old
0 perent	55	63
20 percent	37	42

C. Changes in Forecast Activity

The question of how sensitive the criteria results are to changes in activity forecasts was also addressed. Discontinuance criteria were run using operation counts from the TAF file which were first increased and then decreased by ten percent. With a ten percent increase, exactly the fifteen sites with B/C ratios between 0.9 and 1.0 no longer meet the benefit/cost ratio test for discontinuance. When activity was decreased by ten percent, the ten sites with B/C ratios between 1.0 and 1.09 and three additional sites with ratios of 1.10, 1.11, and 1.13 became tower discontinuance candidates. Since ten percent increases or decreases in traffic activity are not uncommon--particularly at non-towered airports--sites with benefit/cost ratios between 0.90 and 1.10 are considered "borderline" as discussed in Chapters II and V.

VIII. MANUAL METHOD FOR COMPUTING BENEFIT/COST RATIO

In practice, candidates found to satisfy the simple Phase I criteria by the FAA Regions will be screened under Phase II benefit/cost criteria by a computer program. However, to facilitate an understanding of the logic incorporated in the benefit/cost calculations, this Chapter describes in detail a manual method for computing the benefit/cost ratio. The computation method used is not designed to make these calculations as efficient as possible but rather to: (1) illustrate the calculations described in the Chapters III and IV and the logic of the computer program discussed in Chapter IX and (2) provide the reader with some insight regarding the magnitude of intermediate values such as fatalities, and injuries by aircraft class.

The step-by-step procedure is first described and then illustrated by calculating the benefit/cost ratio for a particular site. A brief explanation of how to update the critical values on these worksheets is also provided.

A. Using Worksheets to Calculate Benefit/Cost Ratio

The steps required to calculate the benefit/cost ratio are shown schematically in Figure 8.1 and described below. Figures 8.2 through 8.5 are designed as worksheets for manually computing the tower benefits for one year. To actually calculate the benefits for each of the fifteen years required, these worksheets would be used 15 times. Figure 8.6 is used to calculate the present value of the tower benefits from the 15 annual benefit figures. Figure 8.7 is used to calculate the present value of the costs and the benefit/cost ratio for either discontinuance or establishment.

The first step in calculating the benefit/cost ratio, for either establishment or discontinuance, is choosing the fifteen year analysis time frame. Normally the first year will be the latest year for which actual operation counts are available, followed by 14 years of forecast activity:

Step 1. Enter the fifteen years in column (A) of worksheet 5, figure 8.6.

For each year:

Step 2. Calculate B1 - Reference Figure 8.2, Worksheet 1

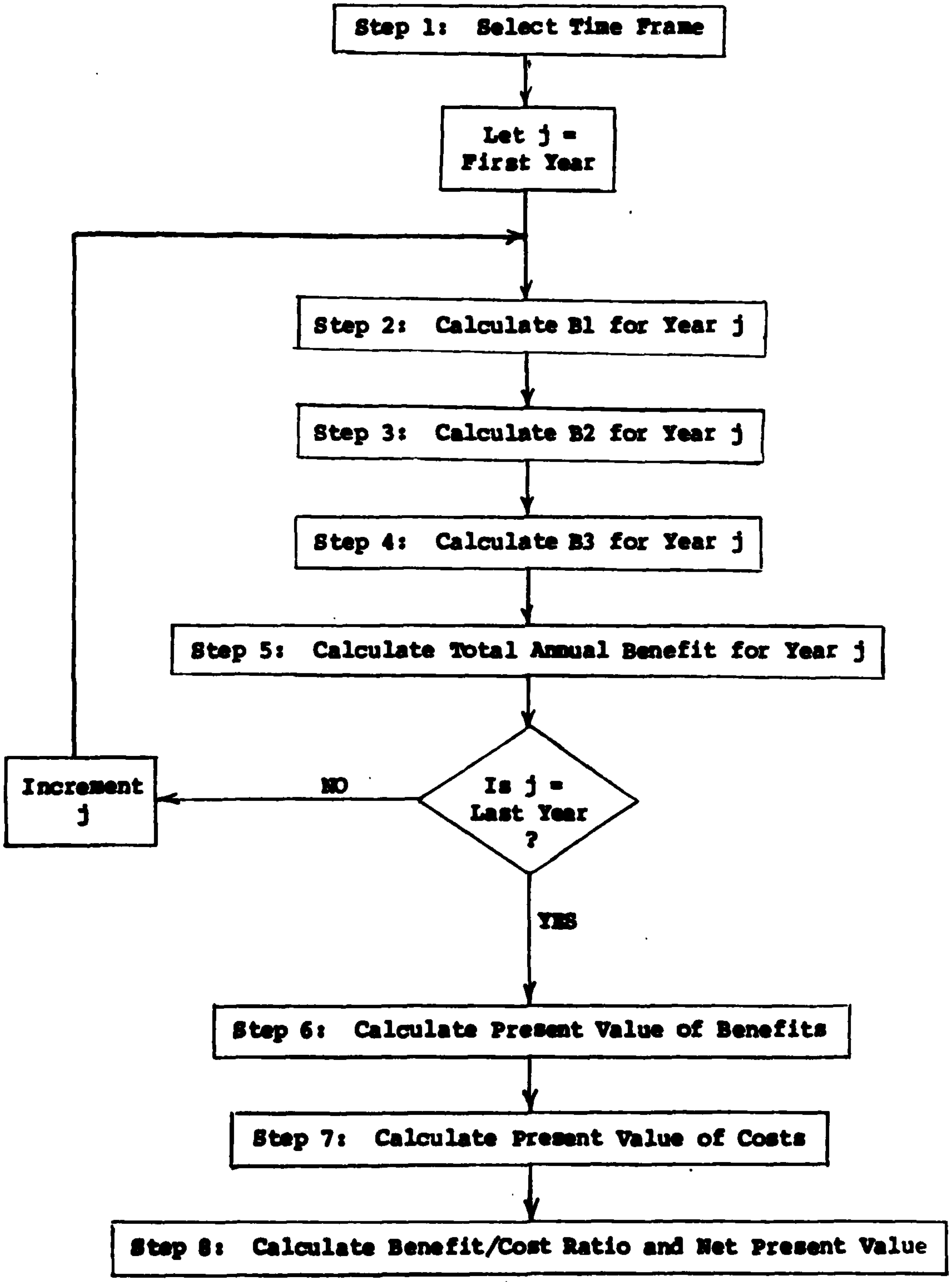


Figure 8.1. Schematic Diagram of Steps used for Manual Calculation of Benefit/Cost Ratio

WORKSHEET 1, Page 1

LOCID ____
YEAR ____

Aircraft Class	(A) Operations This Year OPS(i)	(B) Operations in Millions OPSM(i)	(C) OPSM(i) x OPSALL	(D) Number of Occupants LO(i)	(E) (C) x (D)
1. Air Carrier				40.44	
2. Air Taxi				5.42	
3. General Aviation Itinerant				2.90	
4. General Aviation Local				1.99	
5. Military-Itinerant				4.39	
6. Military-Local				4.39	
TOTALS		OPSALL =			

Aircraft Class	(F) Collision-Fatal Injury Factor	(G) Expected Fatalities in Year (E) x (F)	(H) Collision-Serious Injury Factor	(I) Expected Serious Injuries in Year (E) x (H)	(J) Collision-Minor Injury Factor
1. Air Carrier					
2. Air Taxi					
3. General Aviation Itinerant					
4. General Aviation Local					
5. Military-Itinerant					
6. Military-Local					
TOTALS		IFI =		ISI =	

Figure 8.2 (Page 1 of 2). Computation of Collision Benefit - B1

WORKSHEET 1, Page 2

LOCID ________
YEAR ________

Aircraft Class	(K) Expected Minor Injuries in Year (E) x (J)	(L) Collision-Destroyed Aircraft Factor	(M) Expected Destroyed Aircraft in Year (C) x (L)	(N) Value Destroyed Aircraft ($K) VDS(i)	(O) Destroyed Aircraft Benefit ($K) (M) x (N)
1. Air Carrier				$2771.0	
2. Air Taxi				137.0	
3. General Aviation Itinerant				56.0	
4. General Aviation Local				56.0	
5. Military-Itinerant				1400.0	
6. Military-Local				1400.0	
TOTALS	IMI =				DSI =

Aircraft Class	(P) Collision-Substantially Damaged Aircraft Factor	(Q) Expected Substantially Damaged Aircraft (C) x (P)	(R) Value Substantially Damaged Aircraft ($K) VDM(i)	(S) Substantially-Damaged Aircraft Benefit ($K) (Q) x (R)
1. Air Carrier			$924.0	
2. Air Taxi			46.0	
3. General Aviation Itinerant			19.0	
4. General Aviation Local			19.0	
5. Military-Itinerant			470.0	
6. Military-Local			470.0	
TOTALS				DMI =

B1 = IFI x VF($K) + IS1 x VS($K) + IMI x VM($K) + DSI + DMI

B1 = ________ x $530 + ________ x $38 + ________ x $15 + $________ + $________

B1 = $________ (thousands of dollars)

Figure 8.2 (Page 2 of 2) Computation of Collision Benefit - B1

WORKSHEET 2, Page 1

LOCID ______
YEAR ______

Aircraft Class	(A) Operations This Year OPS(i)	(B) Operations in Millions OPSM(i)	(C) Accident Rate per Million R2(i)	(D) Expected Accidents (B) x (C)	(E) Number of Occupants LO(i)
1. Air Carrier					40.44
2. Air Taxi					5.42
3. General Aviation Itinerant					2.90
4. General Aviation Local					1.99
5. Military-Itinerant					4.39
6. Military-Local					4.39
TOTALS		OPSALL =			

Aircraft Class	(F) Fraction Fatalities FIF2(i)	(G) Expected Fatalities per Accident (E) x (F)	(H) Expected Fatalities in Year (D) x (G)	(I) Fraction Serious Injuries FIS2 (i)	(J) Expected Serious Injuries per Accident (E) x (I)
1. Air Carrier	0.0871			0.0337	
2. Air Taxi	0.0567			0.0565	
3. General Aviation Itinerant	0.0329			0.0497	
4. General Aviation Local	0.0329			0.0497	
5. Military-Itinerant	0.0448			0.0531	
6. Military-Local	0.0448			0.0531	
TOTALS			IF2 =		

Figure 8.3 (Page 1 of 3). Computation of Preventable Accident Benefit - B2

WORKSHEET 2, Page 2

LOCID ______
YEAR ______

Aircraft Class	(K) Expected Serious Injuries in Year (D) x (J)	(L) Fraction Minor Injuries FIM2(i)	(M) Expected Minor Injuries per Accident (E) x (L)	(N) Expected Minor Injuries in Year (D) x (M)	(O) Fraction Aircraft Destroyed FDS2(i)
1. Air Carrier		0.0504			0.1736
2. Air Taxi		0.0962			0.1273
3. General Aviation Itinerant		0.0992			0.1007
4. General Aviation Local		0.0992			0.1007
5. Military-Itinerant		0.0977			0.1140
6. Military-Local		0.0977			0.1140
TOTALS	IS2 =			IM2 =	

Aircraft Class	(P) Expected Destroyed Aircraft in Year (D) x (O)	(Q) Value Destroyed Aircraft ($K) VDS(i)	(R) Destroyed Aircraft Benefit ($K) (P) x (Q)	(S) Fraction Aircraft Substantially Damaged FDM2(i)	(T) Expected Substantially Damaged Aircraft (D) x (S)
1. Air Carrier		$2771.0		0.7917	
2. Air Taxi		137.0		0.8712	
3. General Aviation Itinerant		56.0		0.8962	
4. General Aviation Local		56.0		0.8962	
5. Military-Itinerant		1400.0		0.8837	
6. Military-Local		1400.0		0.8837	
TOTALS			DS2 =		

Figure 8.3 (Page 2 of 3). Computation of Preventable Accident Benefit - B2

WORKSHEET 2, Page 3

LOCID ________
YEAR ________

Aircraft Class	(U) Value Substantially Damaged Aircraft ($K) VDM(i)	(W) Substantially Damaged Aircraft Benefit ($K) (T) x (U)
1. Air Carrier	$924.0	
2. Air Taxi	46.0	
3. General Aviation Itinerant	19.0	
4. General Aviation Local	19.0	
5. Military-Itinerant	470.0	
6. Military-Local	470.0	
TOTAL		DM2 = ________

B2 = IF2 x VF($K) + IS2 x VS($K) + IM2 x VM($K) + DS2 + DM2

= ________ x $530 + ________ x $38 + ________ x $15 + $________ + $________

= $________ (thousands of dollars)

Figure 8.3 (Page 3 of 3). Computation of Preventable Accident Benefit - B2

WORKSHEET 3

LOCID ______
YEAR ______

VT: Value of Time ($ per hour) $17.50

Aircraft Class	(A) Operations this Year OPS(i)	(B) Additional Flying Time per Operation (Hours)	(C) Additional Flying Time for Year (A) x (B)	(D) Number of Passengers LP(i)	(E) Value of Passengers' Time ($) (D) x VT
1. Air Carrier	-	0	-	36.72	$642.60
2. Air Taxi				3.89	68.08
3. General Aviation Itinerant				2.90	50.75
4. General Aviation Local	-	0	-	1.99	34.83
5. Military-Itinerant				4.39	76.83
6. Military-Local	-	0	-	4.39	76.83
TOTALS					

Aircraft Class	(F) Variable Operating Costs ($/Hour) VO(i)	(G) Value of One Hour of Flying ($) (E) + (F)	(H) Value of One Hour of Flying—VHR(i) ($K) (0.001) x (G)	(I) Additional Flying Benefit ($K) (C) x (H)
1. Air Carrier	$962.00	$1640.60	$1.60460	-
2. Air Taxi	163.00	231.08	0.23108	
3. General Aviation Itinerant	73.00	123.75	0.12375	
4. General Aviation Local	73.00	107.83	0.10783	-
5. Military-Itinerant	661.00	737.83	0.73783	
6. Military-Local	661.00	737.83	0.73783	-
TOTALS				B3 =

Figure 8.4. Computation of Benefit from Reduced Flying Time - B3

WORKSHEET 4

LOCID ______
YEAR ______

BLOCK A   If discontinuance criteria:

BT = B1 + B2 + B3

BT = $______________ + $______________ + $______________

BT = $______________ (thousands of dollars)

BLOCK B   If establishment criteria:

B1' = 0.925 x B1 = 0.925 x $______________ = $______________

B2' = 0.925 x B2 = 0.925 x $______________ = $______________

B3' = 0.925 x B3 = 0.925 x $______________ = $______________

BLOCK C   If establishment criteria:

BT = B1' + B2' + B3'

= $______________ + $______________ + $______________

= $______________ (thousands of dollars)

Figure 8.5. Computation of Total Annual Benefit - BT

WORKSHEET 5

LOCID ______

YEAR	(A) Total Benefit BT ($K)	(B) Discount Factor (Based on 10%)	(C) Present Value (A) x (B)
1.		0.953	
2.		0.867	
3.		0.788	
4.		0.716	
5.		0.651	
6.		0.592	
7.		0.538	
8.		0.489	
9.		0.445	
10.		0.404	
11.		0.368	
12.		0.334	
13.		0.304	
14.		0.276	
15.		0.251	
TOTAL			BPV =

Figure 8.6. Computation of Present Value of Benefits - BPV

WORKSHEET 6

LOCID____

Block A If discontinuance criteria:

CPV = (7.977 x COST A) - COST D

CPV = (7.977 x $239) - $118

CPV = $1907 - $118

CPV = $1789 (thousands of dollars)

Block B If establishment criteria

CPV = (7.977 x COST A) + COST E

CPV = (7.977 x $239) + $1,262

CPV = $1907 + $1262

CPV = $3169 thousands of dollars

Block C Benefit/Cost Ratio =

BPV/CPV = $ ____________ / $ ____________

= ____________

Block D Net Present Value =

BPV - CPV = $____________ - $____________

= $____________ (thousands of dollars)

Figure 8.7. Computation of Present Value of Costs and Benefit/Cost Ratio

a. Enter LOCID and year

b. In column (A) enter annual operations by aircraft class.

c. Multiply column (A) entries by 0.000001 to convert operation counts to millions, enter in column (B), and sum. Sum is called OPSALL.

d. Multiply each entry in column (B) by OPSALL and enter in column (C). Note: the sum of the entries in column (C) should equal $OPSALL^2$.

e. In column (E), enter products of columns (C) and (D).

f. Enter collision-injury and damage severity factors from Table 8.1 in the appropriate columns. Use the same factor for each aircraft class:

Column (F)--fatal injury
Column (H)--serious injury
Column (J)--minor injury
Column (L)--destroyed
Column (P)--substantial damage

Table 8.1

Collision-Injury and Damage Severity Factors for Computation of B1 Benefit

Collision-Injury Severity Factors[a]	Establishment	Discontinuance
Fatal: 2 x (RCA x CAIF + RCG x CGIF)	2.151	5.068
Serious: 2 x (RCA x CAIS + RCG x CGIS)	0.782	1.813
Minor: 2 x (RCA x CAIM + RCG x CGIM)	0.614	1.401
Collision-Damange Severity Factors[a]		
Destroyed: 2 x (RCA x CADS + RCG x CGDS)	3.629	8.628
Substantial Damage: 2 x (RCA x CADM + RCG x CGDM)	7.893	21.343

a Values for RCA and RCG are from Table 4.1; injury and damage severity fractions are from Table 4.2.

For example, in column (F) enter 2.151 for establishment or 5.068 for discontinuance.

g. In column (G) enter products of columns (E) and (F) and sum. The sum of the entries in column (G) is IFl, the number of fatalities. Enter IFl on bottom of page 2 of Worksheet 1.

h. In column (I) enter products of columns (E) and (H) and sum. Enter sum, IS1, on bottom of page 2 of Worksheet 1.

i. In column (K) enter products of columns (E) and (J) and sum. Enter sum, IM1, on bottom of page.

j. In column (M) enter products of columns (C) and (L).

k. In column (O) enter products of columns (M) and (N) and sum. The sum of these entries is value of destroyed aircraft in (thousands of dollars). Enter sum, DS1, on bottom of page.

l. In column (Q) enter products of columns (C) and (P).

m. In column (S) enter products of columns (Q) and (R) and sum. Enter sum, DM1, on bottom of page.

n. All blanks in the second line on bottom of page 2 of Worksheet 1 should now be filled in. Perform indicated multiplication and addition to obtain B1.

o. For discontinuance criteria enter B1 in appropriate blanks in Block A of Worksheet 4, Figure 8.4. For establishment criteria, enter in Block B of Worksheet 4.

Step 3. Calculate B2 - Reference Figure 8.3, Worksheet 2.

a. Enter LOCID and year.

b. In column (A) enter annual operations by aircraft class.

c. Multiply column (A) entries by 0.000001 to convert operation counts to millions and enter in column (B).

d. In column (C) enter tower preventable accident rates per million operations from Table 4.4.

e. In column (D) enter products of columns (B) and (C).

f. In column (G) enter products of columns (E) and (F).

g. In column (H) enter products of columns (D) and (G) and sum. The sum of these entries is IF2, the number of fatalities. Enter this sum on bottom of page 3 of Worksheet 2.

h. In column (J) enter products of columns (E) and (I).

i. In column (K) enter products of columns (D) and (J) and sum. Enter sum, IS2, on bottom of page 3 of Worksheet 2.

j. In column (M) enter products of columns (E) and (L).

k. In column (N) enter products of columns (D) and (M) and sum. Enter sum, IM2, on bottom of page 3 of Worksheet 2.

l. In column P enter products of columns (D) and (O).

m. In columns R enter products of columns (P) and (Q) and sum. The sum of this column is DS2, the value of destroyed aircraft (in thousands of dollars). Enter DS2 on bottom of page 3 of Worksheet 2.

n. In column (T) enter products of columns (D) and (S).

o. In column (W) enter products of columns (T) and (U) and sum. Enter sum, DM2, on bottom of page.

p. All blanks in second line on bottom of page 3 of Worksheet 2 should now be filled in. Perform indicated multiplication and addition to obtain B2.

q. For discontinuance criteria, enter B2 in appropriate blanks in Block A of Worksheet 4, Figure 8.5. For establishment criteria, enter B2 in Block B

Step 4: Calculate B3 - Reference Figure 8.4, Worksheet 3.

a. Enter LOCID and year.

b. In column (A) enter annual air taxi, general aviation itinerant, and military itinerant operations.

c. In column (B) enter additional flying time for the three classes: 0.00633 for each class if there is no nearby flight service station, 0.00417 if there is one nearby.

d. In column (C) enter products of columns (A) and (B).

e. In column (I) enter products of columns (C) and (H) and sum. The sum of the entries in these columns is B3.

f. For discontinuance criteria, enter B3 in appropriate blanks in Block A of Worksheet 4, Figure 8.5. For establishment criteria, enter in Block B of this worksheet.

Step 5. Calculate Total Annual Benefit - Reference Figure 8.5, Worksheet 4.

a. Enter LOCID and year.

b. For discontinuance criteria, entries should be present in Block A for B1, B2 and B3. Calculate BT as shown. Skip next two steps.

c. For establishment criteria, entries should be present in Block B for B1, B2 and B3. Multiply B1, B2, and B3 by 0.925 as shown and enter results in Block C. (If the fraction of total operations which are expected to occur during the hours that the tower is open is different from 0.925, use the actual fraction.)

d. For establishment criteria: Calculate BT as shown in Block C.

e. Enter BT for corresponding year in Column (A) of Worksheet 5, Figure 8.6.

Steps 2 through 5 are repeated for each year of the fifteen-year time frame. At this point all of column (A) of Worksheet 5 will have been filled in.

The benefit/cost ratios can now be calculated as discussed in Steps 6, 7 and 8.

Step 6. Calculate Present Value of Benefits - Reference Figure 8.6, Worksheet 5.

a. Enter LOCID.

b. In column (C) enter the products of columns (A) and (B) and sum to obtain BPV.

c. Enter BPV in Blocks C and D of Worksheet 6, Figure 8.6.

Step 7. Calculate Present Value of Costs - Reference Figure 8.7, Worksheet 6.

a. Blocks A and B contain the default values for annual costs, COSTA, discontinuance investment costs, COSTD, and establishment investment costs, COSTE. If site specific values are to be used, replace the appropriate investment and/or annual costs, using thousands of dollars, and perform the indicated operations to obtain CPV. Be sure that the new costs are given in $1980.

b. Enter appropriate CPV (discontinuance or establishment) in Blocks C and D.

Step 8. Calculate Benefit/Cost Ratio and Net Present Value - Reference Figure 8.7, Worksheet 6.

a. Perform indicated division in Block C to obtain Benefit/Cost Ratio.

b. Perform indicated subtraction in Block D to obtain Net Present Value.

B. Illustrative Example of Computation

Figures 8.8 through 8.11 illustrate the benefit calculations for tower establishment for Prescott, Az, for one year 1980. Figures 8.12 and 8.13 complete the benefit cost calculations for this site using 1981 through 1994 benefits which are calculated in a similar method to the 1980 benefits. Although four significant digits, as many as six decimal places, are used in the calculations to minimize round-off errors, results should be given to no more than three significant figures, or in thousands of dollars.

C. Adjusting Critical Values and Costs

One feature of these tower criteria, not present in previous criteria, is the capacity to easily update the critical values and costs to reflect differences in inflation rates among these values and costs. To update these 1980 values and costs using the manual computation method, the dollar values given in Figures 8.2 through 8.7 must all be changed to inflated dollars for one fixed year. How to inflate these values is discussed in detail in References 2 and 3.

In order to update or use site-specific values for tower costs, it is necessary to rework the relevant computations in Tables 3-1 thru 3-3. Salary costs in Table 3.1 must be increased by the benefit factor and in Table 3.2 by both benefit and leave factors as discussed in Section III.A.

WORKSHEET 1, Page 1

LOCID PRC
YEAR 1980

Aircraft Class	(A) Operations This Year OPS(i)	(B) Operations in Millions OPSM(i)	(C) OPSM(i) x OPSALL	(D) Number of Occupants LO(i)	(E) (C) x (D)
1. Air Carrier	1,646	0.001646	0.000377	40.44	0.015246
2. Air Taxi	1,200	0.001200	0.000275	5.42	0.001491
3. General Aviation Itinerant	36,000	0.036000	0.008256	2.90	0.023942
4. General Aviation Local	190,000	0.190000	0.043572	1.99	0.086708
5. Military-Itinerant	240	0.000240	0.000055	4.39	0.000241
6. Military-Local	240	0.000240	0.000055	4.39	0.000241
TOTALS		OPSALL = 0.229326	0.052590		

Aircraft Class	(F) Collision-Fatal Injury Factor	(G) Expected Fatalities in Year (E) x (F)	(H) Collision-Serious Injury Factor	(I) Expected Serious Injuries in Year (E) x (H)	(J) Collision-Minor Injury Factor
1. Air Carrier	2.151	0.03279	0.782	0.01192	0.614
2. Air Taxi		0.00321		0.00117	
3. General Aviation Itinerant		0.05150		0.01872	
4. General Aviation Local		0.18651		0.06781	
5. Military-Itinerant		0.00052		0.00019	
6. Military-Local		0.00052		0.00019	
TOTALS		IFI = 0.27505		ISI = 0.09999	

Figure 8.8 (Page 1 of 2). Illustrative Computation of Collision Benefit - B1

WORKSHEET 1, Page 2

LOCID PRC
YEAR 1980

Aircraft Class	(K) Expected Minor Injuries in Year (E) x (J)	(L) (Accident-Destroyed Aircraft Factor) x 2	(M) Expected Destroyed Aircraft in Year (C) x (L)	(N) Value Destroyed Aircraft ($K) VDS(i)	(1) Destroyed Aircraft Benefit ($K) (M) x (N)
1. Air Carrier	0.00936	3.629	0.00137	$2771.0	$3.7911
2. Air Taxi	0.00092		0.00100	137.0	0.1367
3. General Aviation Itinerant	0.01470		0.02996	56.0	1.6778
4. General Aviation Local	0.05324		0.15812	56.0	8.8549
5. Military-Itinerant	0.00015		0.00020	1400.0	0.2794
6. Military-Local	0.00015		0.00020	1400.0	0.2794
TOTALS	IMI = 0.07852				DSI = $15.019

Aircraft Class	(P) (Accident-Substantially Damaged Aircraft Factor) x 2	(Q) Expected Substantially Damaged Aircraft (C) x (P)	(R) Value Substantially Damaged Aircraft ($K) VDM(i)	(S) Substantially Damaged Aircraft Benefit ($K) (Q) x (R)
1. Air Carrier	7.893	0.00298	$924.0	$2.7495
2. Air Taxi		0.00217	46.0	0.0998
3. General Aviation Itinerant		0.06516	19.0	1.2381
4. General Aviation Local		0.34391	19.0	6.5344
5. Military-Itinerant		0.00043	470.0	0.2040
6. Military-Local		0.00043	470.0	0.2040
TOTALS				DMI = $11.030

B1 = IFI x VF($K) + IS1 x VS($K) + IMI x VM($K) + DSI + DMI

B1 = 0.27505 x $530 + 0.09999 x $38 + 0.07852 x $15 + $15.019 + $11.030

B1 = 176.80 (thousands of dollars)

Figure 8.8 (Page 2 of 2). Illustrative Computation of Collision Benefit - B1

WORKSHEET 2, Page 1

LOCID PRC
YEAR 1980

Aircraft Class	(A) Operations This Year OPS(i)	(B) Operations in Millions OPSM(i)	(C) Accident Rate per Million R2(i)	(D) Expected Accidents (B) x (C)	(E) Number of Occupants LO(i)
1. Air Carrier	1,646	0.001646	2.5830	0.004252	40.44
2. Air Taxi	1,200	0.001200	5.1660	0.006199	5.42
3. General Aviation Itinerant	36,000	0.036000		0.185976	2.90
4. General Aviation Local	140,000	0.190000		0.981540	1.99
5. Military-Itinerant	240	0.000240		0.001240	4.39
6. Military-Local	240	0.000240		0.001240	4.39
TOTALS		OPSALL = 0.229326			

Aircraft Class	(F) Fraction Fatalities FIF2(i)	(G) Expected Fatalities per Accident (E) x (F)	(H) Expected Fatalities in Year (D) x (G)	(I) Fraction Serious Injuries FIS2 (i)	(J) Expected Serious Injuries per Accident (E) x (I)
1. Air Carrier	0.0871	3.52232	0.01498	0.0337	1.36283
2. Air Taxi	0.0567	0.30731	0.00191	0.0565	0.30623
3. General Aviation Itinerant	0.0329	0.09541	0.01774	0.0497	0.14413
4. General Aviation Local	0.0329	0.06547	0.06426	0.0497	0.09890
5. Military-Itinerant	0.0448	0.19667	0.00024	0.0531	0.23311
6. Military-Local	0.0448	0.19667	0.00024	0.0531	0.23311
TOTALS			IF2 = 0.09938		

Figure 8.9 (Page 1 of 3). Illustrative Computation of Preventable Accident Benefit - B2

WORKSHEET 2, Page 2

LOCID PRC
YEAR 1980

Aircraft Class	(K) Expected Serious Injuries in Year (D) x (J)	(L) Fraction Minor Injuries FIM2(i)	(M) Expected Minor Injuries per Accident (E) x (L)	(N) Expected Minor Injuries in Year (D) x (M)	(O) Fraction Aircraft Destroyed FDS2(i)
1. Air Carrier	0.00579	0.0504	2.03818	0.00867	0.1736
2. Air Taxi	0.00190	0.0962	0.52140	0.00323	0.1273
3. General Aviation Itinerant	0.02681	0.0992	0.28768	0.05350	0.1007
4. General Aviation Local	0.09707	0.0992	0.19741	0.19377	0.1007
5. Military-Itinerant	0.00029	0.0977	0.42890	0.00053	0.1140
6. Military-Local	0.00029	0.0977	0.42890	0.00053	0.1140
TOTALS	IS2 = 0.13215			IM2 = 0.26023	

Aircraft Class	(P) Expected Destroyed Aircraft in Year (D) x (O)	(Q) Value Destroyed Aircraft ($K) VDS(i)	(R) Destroyed Aircraft Benefit ($K) (P) x (Q)	(S) Fraction Aircraft Substantially Damaged FDM2(i)	(T) Expected Substantially Damaged Aircraft (D) x (S)
1. Air Carrier	0.000738	$2771.0	$2.0452	0.7917	0.003367
2. Air Taxi	0.000789	137.0	0.1081	0.8712	0.005401
3. General Aviation Itinerant	0.018728	56.0	1.0488	0.8962	0.166672
4. General Aviation Local	0.098841	56.0	5.5351	0.8962	0.879656
5. Military-Itinerant	0.000141	1400.0	0.1979	0.8837	0.001096
6. Military-Local	0.000141	1400.0	0.1979	0.8837	0.001096
TOTALS			DS2 = $9.133		

Figure 8.9 (Page 2 of 3). Illustrative Computation of Preventable Accident Benefit-B2

WORKSHEET 2, Page 3

LOCID PRC
YEAR 1980

Aircraft Class	(U) Value Substantially Damaged Aircraft ($K) VDM(i)	(W) Substantially Damaged Aircraft Benefit ($K) (T) x (U)
1. Air Carrier	$924.0	$3.1110
2. Air Taxi	46.0	0.2484
3. General Aviation Itinerant	19.0	3.1668
4. General Aviation Local	19.0	16.7135
5. Military-Itinerant	470.0	0.5150
6. Military-Local	470.0	0.5150
TOTAL		DM2 = $24.270

B2 = IF2 x VF($K) + IS2 x VS($K) + IM2 x VM($K) + DS2 + DM2

= 0.099378 x $530 + 0.13215 x $38 + 0.26023 x $15 + $9.133 + $24.270

= $95.00 (thousands of dollars)

Figure 8.9 (Page 3 of 3). Illustrative Computation of Preventable Accident Benefit - B2

WORKSHEET 3

LOCID PRC
YEAR 1980

VT: Value of Time ($ per hour) $17.50

Aircraft Class	(A) Operations this Year OPS(i)	(B) Additional Flying Time per Operation (Hours)	(C) Additional Flying Time for Year (A) x (B)	(D) Number of Passengers LP(i)	(E) Value of Passengers' Time ($) (D) x VT
1. Air Carrier	-	0	-	36.72	$642.60
2. Air Taxi	1,200	0.00633	7.5960	3.89	68.08
3. General Aviation Itinerant	36,000	0.00633	227.8800	2.90	50.75
4. General Aviation Local	-	0	-	1.99	34.83
5. Military-Itinerant	240	0.00633	1.5192	4.39	76.83
6. Military-Local	-	0	-	4.39	76.83
TOTALS					

Aircraft Class	(F) Variable Operating Costs ($/Hour) VO(i)	(G) Value of One Hour of Flying ($) (E) + (F)	(H) Value of One Hour of Flying—VHR(i) ($K) (0.001) x (G)	(I) Additional Flying Benefit ($K) (C) x (H)
1. Air Carrier	$962.00	$1604.60	$1.60460	-
2. Air Taxi	163.00	231.08	0.23108	$1.755
3. General Aviation Itinerant	73.00	123.75	0.12375	28.200
4. General Aviation Local	73.00	107.83	0.10783	-
5. Military-Itinerant	661.00	737.83	0.73783	1.121
6. Military-Local	661.00	737.83	0.73783	-
TOTALS				B3 = $31.076

Figure 8.10. Illustrative Computation of Benefit from Reduced Flying Time - B3

WORKSHEET 4

LOCID PRC
YEAR 1980

BLOCK A — If discontinuance criteria:

BT = B1 + B2 + B3

BT = $________ + $________ + $________

BT = $________ (thousands of dollars)

BLOCK B — If establishment criteria:

B1' = 0.925 x B1 = 0.925 x $176.80 = $163.54

B2' = 0.925 x B2 = 0.925 x $ 95.00 = $ 87.88

B3' = 0.925 x B3 = 0.925 x $ 31.08 = $ 28.75

BLOCK C — If establishment criteria:

BT = B1' + B2' + B3'

= $163.54 + $87.88 + $28.75

= $280.17 (thousands of dollars)

Figure 8.11. Illustrative Computation of Total Annual Benefit - BT

WORKSHEET 5

LOCID PRC

YEAR	(A) Total Benefit $K BT	(B) Discount Factor (Based on 10%)	(C) Present Value (A) x (B)
1. 1980	$280	0.953	$267
2. 1981	364	0.867	316
3. 1982	386	0.788	304
4. 1983	411	0.716	294
5. 1984	437	0.651	284
6. 1985	466	0.592	276
7. 1986	496	0.538	267
8. 1987	528	0.489	258
9. 1988	563	0.445	251
10. 1989	600	0.404	242
11. 1990	640	0.368	236
12. 1991	682	0.334	228
13. 1992	728	0.304	221
14. 1993	776	0.276	214
15. 1994	827	0.251	208
TOTAL			BPV = $3866

Figure 8.12. Illustrative Computation of Present Value of Benefits - BPV

WORKSHEET 6

LOCID <u>PRC</u>

Block A If discontinuance criteria:

CPV = (7.977 x COST A) - COST D

CPV = (7.977 x $239) - $118

CPV = $1907 - $118

CPV = $1789 thousands of dollars

Block B If establishment criteria

CPV = (7.977 x COST A) + COST E

CPV = (7.977 x $239) + $1262

CPV = $1907 + 1262

CPV = $3169 thousands of dollars

Block C Benefit/Cost Ratio =

BPV/CPV = <u>$3866</u> / <u>$3169</u>

= <u>1.22</u>

Block D Net Present Value =

BPV - CPV = <u>$3866</u> - <u>$3169</u>

= <u>$697</u> (thousands of dollars)

Figure 8.13. Illustrative Computation of Present Value of Costs and Benefit/Cost Ratio

In order to update the critical values and costs verify or change the following values before beginning the calculations:

Worksheet 1, Figure 8.2	Columns (N) and (R) and VF, VS, and VM on bottom of page 2.
Worksheet 2, Figure 8.3	Columns (Q) and (U) and VF, VS, and VM on bottom of page 3.
Worksheet 3, Figure 8.4	VT on top of page and columns (E), (F), (G) and (H).
Worksheet 4, Figure 8.5	No changes.
Worksheet 5, Figure 8.6	No changes.
Worksheet 6, Figure 8.7	COSTA, COSTD and COSTE in Blocks A and B.

Provisions are also made in this criteria to use site-specific values for number of occupants or number of passengers. These values can also be easily adjusted by changing the appropriate worksheet columns (before doing the calculations):

Worksheet 1, Figure 8.2	Column (D)
Worksheet 2, Figure 8.3	Column (E)
Worksheet 3, Figure 8.4	Columns (D), (E), (G) and (H)

IX. HOW TO USE THE COMPUTER PROGRAM

Computer software for air traffic control tower criteria has been prepared and is maintained by FAA's Office of Aviation Policy and Plans. This Chapter discusses the current tower criteria program which has generated the results presented in this report. This program is not interactive; however it will be incorporated into APO's interactive criteria system which is now under development. Complete listings of the programs are given in Appendix D.

The tower criteria program uses two input files:

- o Terminal Area Forecast (TAF) Data System
- o Critical Value File.

The TAF file contains one large record for each airport which currently contains reported operation counts from 1976 thru 1981 and forecast operations thru 1995. Complete details concerning TAF may be found in Reference 13.

The Critical Value File, described in Table 9.1, contains all of the critical values, including numbers of occupants and passengers, the three cost values: annual, establishment investment and decommissioning costs, and the percentage of total operations which will occur during the hours an establishment candidate will be open. Variables 3 thru 7 have one value for each of the six aircraft classes--AC, AT, GAI, GAL, MI, and ML. The user may provide site-specific values for any variables in the table except the critical values for time and injuries. Thus, for example, if the air carrier aircraft which operate at a particular location are all jet aircraft, then the air carrier values for variables 3 thru 7 should be changed to the appropriate values for this aircraft mixture. The variables which are expressed in monetary units—1 thru 5 and 8—will be updated periodically by the Office of Aviation Policy and Plans. The values for each of the variables in the critical value file are shown in Table 9.2.

---

[1] When using site-specific values for variables 3, 4, 5, or 8, make sure that the replacement values are in the same year dollars as variables 1 and 2.

Table 9.1

"Critical Vaue" Input File Description

Variable Number	Variable Description	Number of Values	May Use Site-Specific Values	Headquarters Update
1	Injury: Fatal, Serious, Minor ($K)	3	No	Yes
2	Time ($ Per Hour)	1	No	Yes
3	Aircraft Replacement Costs ($K)	6	Yes	Yes
4	Aircraft Restoration Costs ($K)	6	Yes	Yes
5	Variable Operating Costs ($ Per Hour)	6	Yes	Yes
6	Occupants Per Aircraft	6	Yes	No
7	Passengers Per Aircraft	6	Yes	No
8	Costs: Annual, Establishment, Discontinuance ($K)	3	Yes	Yes
9	Percent Total OPS During Proposed Operating Hours	1	Yes	No

Table 9.2

"Critical Value" Input File Values
(1980$)

Variable Description	Values (1)	(2)	(3)	(4)	(5)	(6)
Injury: Fatal, Serious, Minor ($K)	530.00	38.00	15.00			
Time ($ Per Hour)	17.50					
Aircraft Replacement Costs ($K)	2771.00	137.00	56.00	56.00	1400.00	1400.00
Aircraft Restoration Costs ($K)	924.00	46.00	19.00	19.00	470.00	470.00
Variable Operating Costs ($ Per Hour)	962.00	163.00	73.00	73.00	661.00	661.00
Occupants Per Aircraft	40.44	5.42	2.90	1.99	4.39	4.39
Passengers Per Aircraft	36.72	3.89	2.90	1.99	4.39	4.39
Costs: Annual, Establishment, Discontinuance ($K)	239.00	1262.00	-118.00			
Percent Total OPS During Proposed Operating Hours	92.50					

Two integer codes are used to control processing. TCODE, the tower code, obtained from the TAF file and FSCODE, the flight service station (FSS) code, input by the user. If TCODE is equal to 1 (FAA tower) or 2 (new FAA tower), the program runs for the discontinuance case. Otherwise the program runs the establishment case. If FSCODE is less than or equal to zero, the program assumes that there is no nearby FSS in computing the B3 tower benefit. Otherwise, a nearby FSS is assumed.

The program is easily adjusted to begin the 15-year time frame in either 1980 or 1981. It will not be possible to run the program starting in later years, until it is incorporated into the interactive system which provides for forecast extrapolation beyond 1995.

The primary output from the tower criteria program is one line written to a mass storage file (or magnetic tape) for each site processed, which contains exactly the same information provided for each location in Tables 5.1 and 5.2. Various printed outputs are controlled by the values of four flags in the program which are input by the user. Figures 9.1 and 9.2 illustrate all of the printed output available for one site, Prescott, AZ:

FLAGP $\geq$ 0 causes the standard output shown in Figure 9.1 to be printed

FLAGQ $\geq$ 0 causes the annual aircraft operations by class to be printed as shown in Figure 9.2

FLAGB $\geq$ 0 causes the annual tower benefits to be printed (Figure 9.2)

The critical values and costs used are printed (once) if FLAGV $\geq$ 0.

Appendix E shows how to modify the program to run it for one location, some set of locations, or all locations. Record counter values for number of records read, selected, and output are printed out when processing is complete.

A schematic diagram of the main computer program, TOWER, is given in Figure 9.3. All of the benefit calculations are performed by the subroutine TWRBEN. The variable values used by TWRBEN, such as critical values, operation counts, TCODE, and FSCODE are passed to TWRBEN in FORTRAN common. Results are also returned in the common block. The processing in TWRBEN is very similar to Worksheets 1 thru 5, Figures 8.2 thru 8.6, in Chapter VIII. If operations or benefits are zero for a particular location, a message is printed out by the main program and no further output is produced.

```
TOWER CRITERIA RESULTS FOR PRC PRESCOTT              AZ   AWP   TCODE = 0 ,FSCODE = 0

 PHASE ONE RATIO FOR FIRST YEAR =      0.97

   TOTAL CUMULATIVE TOWER BENEFITS AND COSTS FOR THE 15 YEAR PERIOD BEGINING IN 1980
                              DISCOUNT RATE  =  10.0 PERCENT

          BENEFIT CATEGORY                          NOT DISCOUNTED      DISCOUNTED
                                                         ($K)              ($K)
    B1    PREVENTED COLLISIONS                          4931.              2271.
    B2    OTHER PREVENTABLE ACCIDENTS                   1937.               956.
    B3    ADDITIONAL FLYING AVOIDED                     1316.               639.
    B4    OTHER TOWER BENEFITS                             0.                 0.

          TOTAL TOWER BENEFITS                          8183.              3866.

          TOTAL TOWER COSTS                             4847.              3169.

          TOTAL TOWER BENEFITS MINUS COSTS              3336.               697.

          RATIO: TOWER BENEFITS/COSTS                    1.69               1.22

 FATAL, SERIOUS, MINOR INJURIES FOR 15 YEARS       9.74         5.47        7.44

 COLLISIONS, OTHER ACCIDENTS FOR 15 YEARS          8.76        21.62
```

Figure 9.1 Optional Printed Output Controlled by FLAGP

PRC PRESCOTT AZ AWP TCODE = 0, FSCODE = 0

ANNUAL AIRCRAFT OPERATIONS BY CLASS

YEAR	AC	AT	GAI	GAL	MI	ML
1980	1646.	1200.	36000.	190000.	240.	240.
1981	2000.	2000.	90000.	140000.	1000.	240.
1982	2110.	2130.	93339.	145922.	1000.	240.
1983	2226.	2290.	96802.	152095.	1000.	240.
1984	2348.	2468.	100393.	158529.	1000.	240.
1985	2476.	2678.	104118.	165235.	1000.	240.
1986	2612.	2838.	107981.	172224.	1000.	240.
1987	2756.	3016.	111987.	179509.	1000.	240.
1988	2906.	3176.	116142.	187102.	1000.	240.
1989	3066.	3354.	120451.	195016.	1000.	240.
1990	3234.	3484.	124920.	203265.	1000.	240.
1991	3414.	3612.	129555.	211863.	1000.	240.
1992	3584.	3742.	134361.	220825.	1000.	240.
1993	3764.	3742.	139346.	230166.	1000.	240.
1994	3952.	3742.	144516.	239902.	1000.	240.

ANNUAL TOWER BENEFITS ($K)

	PHASE I	BENEFIT CATEGORIES				TOTAL	CUMULATIVE	
YEAR	RATIO	B1	B2	B3	B4	FOR YEAR	NOT DISCOUNTED	DISCOUNTED
1980	0.97	164.	88.	29.	0.	280.	280.	267.
1981	1.16	191.	100.	72.	0.	364.	644.	582.
1982	1.21	207.	104.	75.	0.	386.	1030.	887.
1983	1.26	225.	109.	78.	0.	411.	1441.	1181.
1984	1.31	244.	113.	80.	0.	437.	1879.	1466.
1985	1.36	264.	118.	83.	0.	466.	2344.	1742.
1986	1.41	287.	123.	86.	0.	496.	2840.	2008.
1987	1.47	311.	128.	90.	0.	528.	3368.	2267.
1988	1.53	337.	133.	93.	0.	563.	3931.	2517.
1989	1.59	365.	139.	96.	0.	600.	4531.	2760.
1990	1.65	396.	144.	100.	0.	640.	5170.	2995.
1991	1.72	429.	150.	103.	0.	682.	5853.	3223.
1992	1.79	465.	156.	107.	0.	728.	6580.	3444.
1993	1.86	503.	163.	110.	0.	776.	7356.	3658.
1994	1.93	544.	169.	114.	0.	827.	8183.	3866.

Figure 9.2 Additional Optional Printed Output

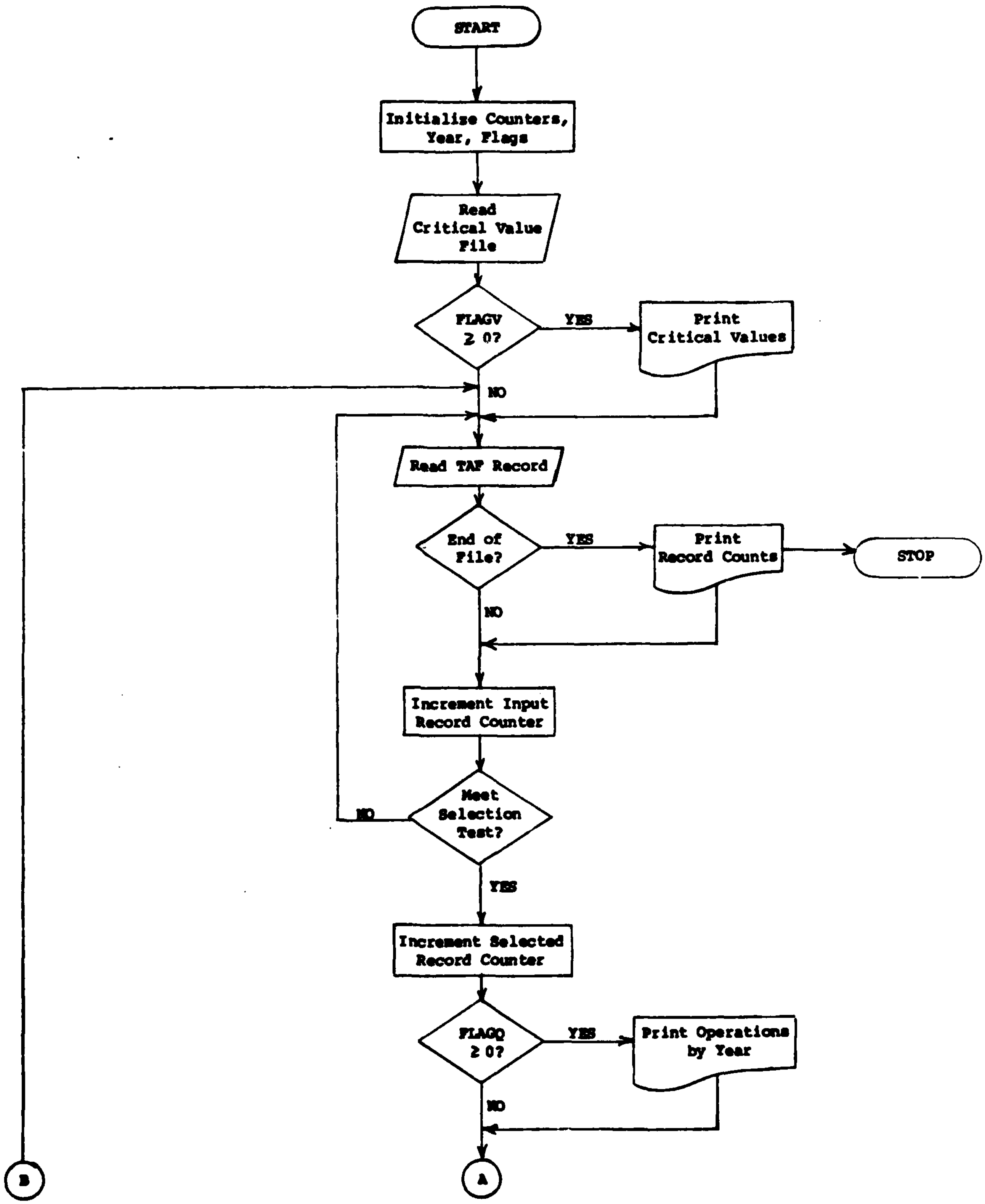
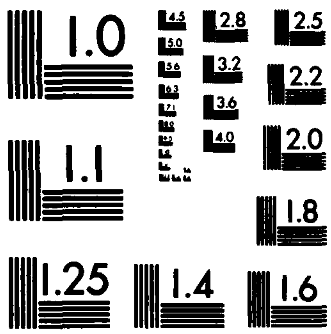


Figure 9.3 (Page 1 of 2). Schematic Diagram of TOWER Program

AD-A133 461 ESTABLISHMENT AND DISCONTINUANCE CRITERIA FOR AIRPORT TRAFFIC CONTROL TOWERS(U) FEDERAL AVIATION ADMINISTRATION WASHINGTON DC OFFICE OF AVIAT.. 2/2

UNCLASSIFIED S G HELZER AUG 83 FAA-APO-83-2 F/G 17/7 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

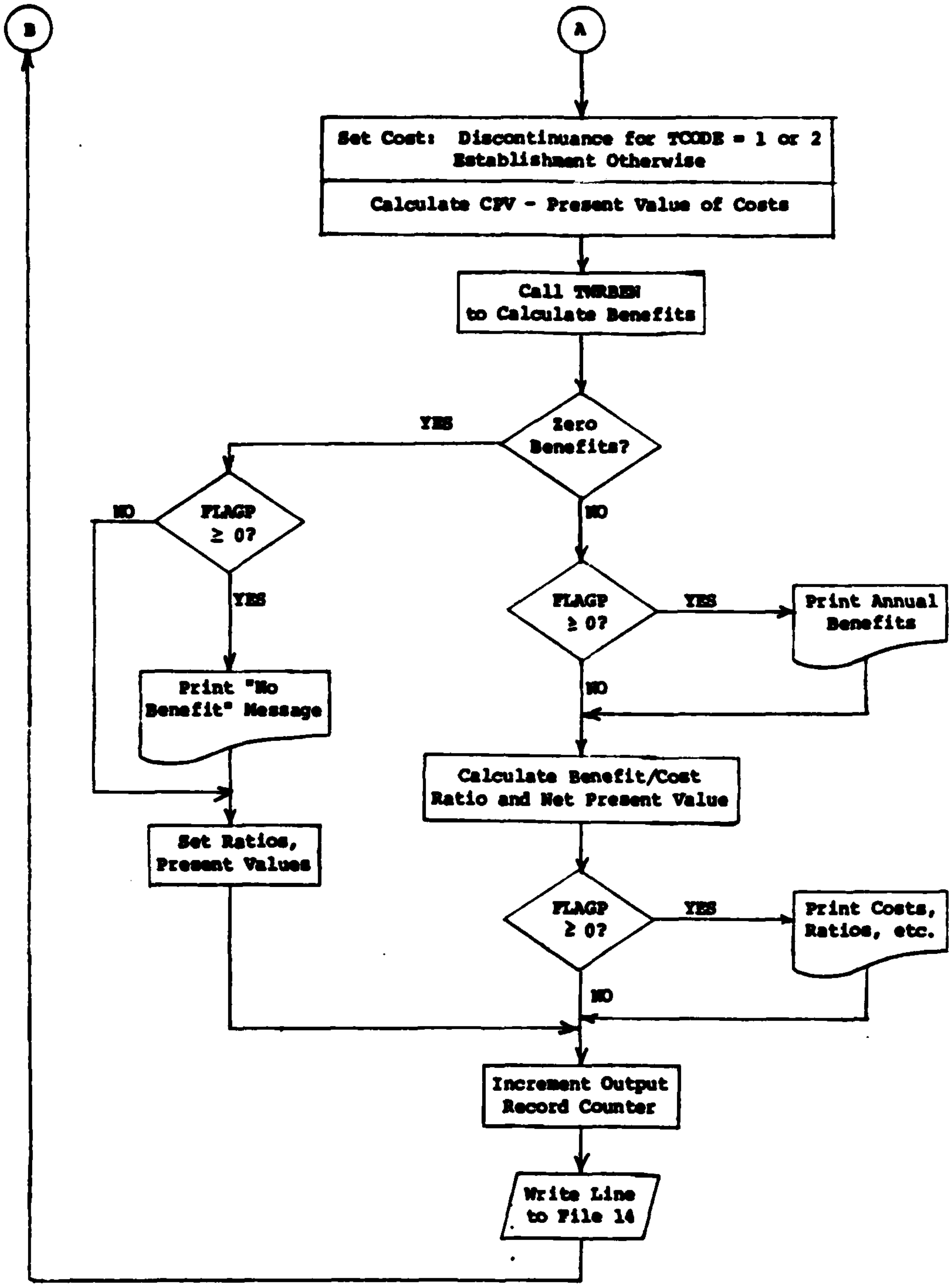


Figure 9.3 (Page 2 of 2). Schematic Diagram of TOWER Program

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2. Economic Analysis of Investment and Regulatory Decisions--A Guide, Report Number FAA-APO-82-1, FAA, January 1982.

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15. Investment Criteria for Airport Surveillance Radar (ASR/ATCRABS/ARTS), Draft Report, Number FAA-APO-81-13, FAA, November 1981.

16. General Aviation Pilot and Aircraft Activity Survey, Report Number FAA-MS-79-7, FAA, December 1979.

17. 1978 General Aviation Activity and Avionics Survey, Report Number FAA-MS-80-5, FAA, Office of Management Systems, March 1980.

APPENDIX A: CRITICAL VALUES

The "critical values" used in this report are shown in Table A.1. These values include the economic values used by the FAA to evaluate investment and regulatory programs: value of time of air travelers, value of a statistical life, unit costs (value) of statistical aviation injuries, unit restoration and replacement costs of damaged and destroyed aircraft, and aircraft variable operating costs. A complete discussion of why these values are used in FAA's economic analyses is given in Reference 2. These values are directly from Reference 3 except for the air carrier values which are derived below.

Included with tower criteria "critical values" are average numbers of occupants and passengers per aircraft, also derived below. Occupant figures, used to calculate safety benefits, include crew; passenger figures, used to calculate delay benefits, exclude crew for air carriers and air taxis since the value of the crew's time is included in the variable operating costs as salary and wages.

Calculating Critical Values for Air Carrier

Reference 3 reports replacement/restoration costs and variable operating costs for nine categories of air carrier aircraft. Average values for the entire air carrier fleet are also reported. However, these average values do not represent the average of the generally smaller air carrier aircraft which land at the type of airport which would be a candidate for air traffic control tower establishment or discontinuance. Therefore, in order to obtain the appropriate critical values for air carrier aircraft operating at potential tower candidates, a sample of twenty-five towered airports was chosen. Each of these airports had at least 100 air carrier operations in 1979 and benefit/cost ratios less than 1.35 (according to old tower discontinuance criteria run on 1980 Terminal Area Forecasts). Aircraft departures by aircraft type, determined for each airport from (Reference 14), ranged from 3653 (Flagstaff, AZ) to 248 (Bloomington-Normal, IL). The 31,794 departures at the twenty-five sites were distributed over the nine aircraft types as shown in Table A.2. The fractions of each aircraft type were then applied to the associated air carrier values to obtain a weighted average for the replacement costs and variable operating costs as calculated in Table A.3. The average restoration cost is 1/3 of the average replacement cost (Reference 3). Table A.4 shows similar calculations for the average number of air carrier occupants (including crew) and passengers (excluding crew).

Table A.1

Critical Values and Costs Used in Tower Criteria

Fatal, Serious, Minor Injury ($K)	530.00	38.00	15.00		
Passenger Time ($ Per Hour)	17.50				
	AC	AT	GAI	GAL	MI & ML
Replacement Costs ($K)	2771.00	137.00	56.00	56.00	1400.00
Restoration Costs ($K)	924.00	46.00	19.00	19.00	470.00
Operating Costs ($ Per Hour)	962.00	163.00	73.00	73.00	661.00
Occupants Per Aircraft	40.44	5.42	2.90	1.99	4.39
Passengers Per Aircraft	36.72	3.89	2.90	1.99	4.39

Table A.2

Distribution of Air Carrier Aircraft Used in Development of Critical Values

Air Carrier Type	Departures	Fraction
Turbojet	0	0.00
Turbofan, 4 engine, wide body	0	0.00
Turbofan, 4 engine, regular body	0	0.00
Turbofan, 3 engine, wide body	446	0.0140
Turbofan, 3 engine, regular body	950	0.0299
Turbofan, 2 engine, wide body	0	0.00
Turbofan, 2 engine, regular body	10,534	0.3313
Turboprop	15,476	0.4868
Piston	4,388	0.1380
Total	31,794	-

Table A.3

Calculation of Air-Carrier Replacement/Restoration Costs and Variable Operating Costs

Air Carrier Type	(A) Distribution by Type	(B) Replacement Cost[a]	(C) (A)x(B)	(D) Cost per Airborne Hr.[b]	(E) (A) x (D)
Turbofan, 3 engine, wide body	0.0140	$20,500,000	$ 287,570	$3341	$ 46.87
Turbofan, 3 engine, regular body	0.0299	4,000,000	119,515	1964	58.68
Turbofan, 2 engine, regular body	0.3313	5,100,000	1,689,734	1508	499.63
Turboprop (all)	0.4868	1,300,000	632,786	694	337.81
Piston	0.1380	300,000	41,404	139	19.18
Weighted Average			$2,771,000[c] Replacement Cost		$962.00[c] Operating Cost

Average Restoration Cost = 1/3 x Average Replacement Cost
= 1/3 x $2,771,000
= $924,000[c]

---

a From Reference 3, p. ii

b From Reference 3, p. iii

c Rounded to thousands of dollars

Table A.4

Calculation of Number of Occupants and Passengers in Air Carriers

Air Carrier Type	(A) Distribution by Type	(B) Number of Occupants[a]	(C) (A) x (B)	(D) Number of Passengers[b]	(E) (A) x (D)
Turbofan, 3 engine, wide body	0.0140	169.5	2.3777	158.5	2.2234
Turbofan, 3 engine, regular body	0.0299	84.4	2.5219	78.4	2.3426
Turbofan, 2 engine, regular body	0.3313	66.6	22.0659	61.6	20.4093
Turboprop (all)	0.4868	26.5	12.8991	23.5	11.4388
Piston	0.1380	4.2	0.5797	2.2	0.3036
Weighted Average			40.44[c] Occupants		36.72[c] Passengers

---

a From Reference 14, p. 97

b From Reference 14, p. 89

c Rounded to four significant figures

Calculating Numbers of Occupants and Passengers for Other Aircraft Classes

Table A.5 shows the calculations for the average number of occupants (including crew) and the average number of passengers (excluding crew) for air taxi.

The calculation of the average number of occupants for local and itinerant general aviation and military are shown in Tables A.6 and A.7. Since no crew salaries or wages are included in the variable operating costs for these aircraft, the number of passengers used in calculating the benefit of additional flying time avoided, B3, is equal to the number of occupants. The calculations for general aviation aircraft are somewhat more involved than the other calculations: First, the general aviation hours flown for each aircraft type are distributed between itinerant are local. Then, these figures are used to calculate separate fractional distributions by aircraft type for itinerant and local, before proceeding with the usual weighted average computation.

Updating Critical Values

Critical values used in FAA's investment criteria, including air traffic control tower criteria, should be updated annually as described in References 2 and 3. To update the air carrier replacement and restoration costs as well as air carrier variable operating costs, simply update the values in columns (B) and (D) of Table A.3, perform the indicated multiplications to obtain columns (C) and (E) and sum these columns. The restoration cost is 1/3 of the replacement cost. Figures for numbers of occupants and passengers may also be updated by following the procedures outlined in Tables A.4 through A.7. It is unlikely that these values require annual updating, nevertheless, the computer program described in Chapter IX was written to make this procedure a simple one.

Table A.5

Calculation of Average Number of Occupants and Passengers in Air Taxis (Including Commuters)

Air Carrier Type	(A) Distribution by Type[a]	(B) Number of Occupants[b]	(C) (A)x(B)	(D) Number of Passengers[c]	(E) (C)x(D)
Jet	0.030	4.3	0.129	2.3	0.069
Turboprop	0.125	9.3	1.163	7.3	0.913
Multi-engine piston	0.382	7.4	2.827	5.4	2.063
Single engine piston	0.275	3.1	0.853	2.1	0.578
Rotocraft	0.188	2.4	0.451	1.4	0.263
Weighted Average			5.42 Occupants		3.89 Passengers

a From Reference 15, p. 100

b From Reference 15, p. 97

c From Reference 15, p. 89

Table A.6 (Page 1)

Calculation of Number of Occupants
in Local and Itinerant General Aviation Aircraft

General Aviation Type	(A) Percent for Each Type Itinerant[a]	(B) Local[a]	(C) Hours Flown Itinerant[b]	(D) Local[b]	(E) Distributions by Type Itinerant	(F) Local
Jet	93.6	6.4	1,090,767	74,582	0.057	0.004
Turboprop	89.8	10.2	1,349,100	153,239	0.071	0.009
Multi-engine piston	78.5	21.5	3,969,946	1,087,310	0.208	0.063
Single-engine piston - 4 or more seats	52.2	47.8	9,704,166	8,886,191	0.507	0.511
Single-engine piston - 1 to 3 seats	27.3	72.7	2,304,914	6,233,861	0.122	0.358
Turbine rotocraft	50.0	50.0	362,632	362,632	0.016	0.021
Piston rotocraft	34.1	65.9	308,262	595,733	0.019	0.034
Total			19,125,787	17,393,548		

a From Reference 16

b Columns (C) and (D) are obtained by applying the percentage of itinerant and local for each type to total hours flown in that type from Reference 17.

Table A.6 (Page 2)

Calculation of Number of Occupants
in Local and Itinerant General Aviation Aircraft

	(G)	(H)	(I)	(J)
	Number of Occupants			
General Aviation Type	Itinerant[a]	Local[a]	(E)x(G)	(F)x(H)
Jet	4.23	2.33	0.241	0.009
Turboprop	5.74	3.87	0.408	0.035
Multi-engine piston	3.74	2.89	0.778	0.182
Single engine piston - 4 or more seats	2.39	2.10	1.212	1.073
Single engine piston - 1 to 3 seats	1.46	1.62	0.178	0.580
Turbine rotocraft	2.54	2.77	0.048	0.058
Piston rotocraft	2.07	1.68	0.033	0.057
Weighted average			2.90 Itinerant	1.99 Local

Table A.7

Calculation of Number of Occupants in Military Aircraft

Military Type	(A) Distribution by Type[a]	(B) Number of Occupants[b]	(A) x (B)
Jet	0.588	6.0	3.53
Turboprop	0.123	5.0	0.62
Piston	0.068	3.0	0.20
Rotorcraft	0.0221	2.0	0.04
Weighted Average			4.39

---

a From Reference 15, p. 100

b From Reference 15, p. 89 and 97

APPENDIX B: DEVELOPMENT OF COLLISION DATA

This Appendix documents details of the B1 benefit calculations which are not included in Chapter IV: the extension of the collision analysis results (Reference 7) for general aviation and air taxi to the six classes of aircraft in our analysis, and the derivation of the statistical confidence interval used to calculate B1 for tower discontinuance criteria.

Extension of Collision Functions to Multiple Aircraft Classes

We assume that the collision functions CA_T, CA_{XT}, CG_T, and CG_{XT} in Section IV.A apply to all six aircraft classes. The following example shows how to extend results for one class to three aircraft classes.

Suppose three aircraft classes, 1, 2 and 3, have n_1, n_2 and n_3 operations in one year, where $n_1 + n_2 + n_3 = N$. Suppose that there are C accidents per "potential collision pair" regardless of aircraft class.

Case 1: The number of "potential collision pairs" of aircraft in the same class i is approximately

$(n_i \times n_i)/2$.

Thus we expect

$(C \times n_i \times n_i)/2$

collisions involving

$C \times n_i \times n_i$

class i aircraft (two aircraft in each collision).

Case 2: The number of "potential collision pairs" of aircraft in different classes i, j is simply

$n_i \times n_j$.

Thus we expect

$C \times n_i \times n_j$

collisions between class i and class j aircraft involving

$$C \times n_i \times n_j$$

aircraft from each class.

Table B.1 shows how to calculate the number of aircraft involved in collisions for each class. For example the number of class 1 aircraft involved in collisions is the sum of the number which collide with each class, namely $C \times n_1 \times N$. The total number of collisions for all classes is $C \times N^2/2$; the total number of aircraft in all classes involved is

$$(C \times n_1 \times N) + (C \times n_2 \times N) + (C \times n_3 \times N)$$

$$= C \times (n_1 + n_2 + n_3) \times N$$

$$= C \times N^2$$

namely two aircraft per collision (as expected).

The above results are easily extended to six classes. However, C is used above as the number of accident per collision pair, namely per $N^2/2$, but the collision coefficients used in this report are for N^2 rather than $N^2/2$. Thus, for example, if the number of collisions avoided by operating a tower for one year is

$$R1 \times (OPS/10^6)^2$$

then

$$2 \times R1 \times (OPS/10^6)^2$$

aircraft are involved per year. The number of collisions involving two class i aircraft is

$$R1 \times \left[OPSM(i)\right]^2$$

and

$$2 \times R1 \times \left[OPSM(i)\right]^2$$

class i aircraft are involved in these collisions (two aircraft in each collision), where

R1 = a collision coefficient from Table 4.1

OPSM(i) = operations for aircraft class i <u>in millions</u>

The number of collisions involving one class i aircraft and one aircraft from a different class j is

Table B.1

Example Calculating Expected Number of Each Class of Aircraft Involved in Collisions

Aircraft Class Combination	Number of Collisions[a]	Number of Aircraft Involved: Class 1	Class 2	Class 3
1, 1	$C \times n_1 \times n_1/2$	$C \times n_1 \times n_1$		
1, 2	$C \times n_1 \times n_2$	$C \times n_1 \times n_2$	$C \times n_1 \times n_2$	
1, 3	$C \times n_1 \times n_3$	$C \times n_1 \times n_3$		$C \times n_1 \times n_3$
2, 2	$C \times n_2 \times n_2/2$		$C \times n_2 \times n_2$	
2, 3	$C \times n_2 \times n_3$		$C \times n_2 \times n_3$	$C \times n_2 \times n_3$
3, 3	$C \times n_3 \times n_3/2$			$C \times n_3 \times n_3$
Total	$C \times (n_1 + n_2 + n_3)^2/2$ $\approx C \times N^2/2$	$C \times n_1 \times (n_1 + n_2 + n_3)$ $\approx C \times n_1 \times N$	$C \times n_2 \times (n_1 + n_2 + n_3)$ $\approx C \times n_2 \times N$	$C \times n_3 \times (n_1 + n_2 + n_3)$ $\approx C \times n_3 \times N$

a The number of combinations of two elements that can be drawn from a set of n elements is $n(n-1)/2$. For large n, this is approximately equal to $n^2/2$.

$$2 \times R1 \times OPSM(i) \times OPSM(j)$$

and

$$2 \times R1 \times OPSM(i) \times OPSM(j)$$

class i aircraft are involved in these collisions. (There are, of course, an equal number of class j aircraft involved.) The total number of class i aircraft involved in all collisions is

$$2 \times R1 \times OPSM(i) \times OPSALL$$

where

$$OPSALL = \sum_{i=1}^{6} OPSM(i) \text{ (also in millions)}$$

Calculation of Confidence Intervals

We assume that the number of collisions at towered and non-towered airports are Poisson distributed. To calculate a confidence interval for the difference of two Poisson distributions, the distribution of this difference may be constructed. In both cases, collisions with one or more aircraft airborne and ground-to-ground collisions, the differences were relatively complex distributions, which did not approach any well known distribution types, with readily available formulas for confidence intervals and other such statistics. Thus the following method was used to develop an approximation to the desired confidence limit of the actual distribution. The difference of the two Poisson distributions was constructed, using the upper bound of the 95-percent confidence interval for non-towered airports and the lower bound of the 95-percent confidence interval for towered airports. The mean value of this distribution represents an approximate upper bound of a 95-percent confidence interval. The resulting values, for both collision cases, are given in Chapter IV, Table 4.1.

APPENDIX C. DEVELOPMENT OF OTHER TOWER PREVENTABLE ACCIDENT DATA

This Appendix discusses additional details of the B2 benefit calculations: the derivation of the injury and damage severity fractions and the statistical confidence limit used for tower discontinuance criteria.

Injury and Damage Severity Fractions

The National Transportation Safety Board (NTSB) maintains computer summaries of all accidents involving U.S. civil and foreign registered aircraft on U.S. soil between 1964 and 1979. These data files were queried to obtain data on the six categories of accidents judged to be tower preventable (Section IV.B). There were 144 air carrier, 652 air taxi, and 14,434 general aviation accidents in these six categories during these fifteen years, which occurred within 5 miles of an airport, during taxi, take-off, climb to cruise, descending, holding, or landing phase of operation.

These accidents, distributed by type as shown in Table C.1, were used to develop the fatality, injury, and aircraft damage fractions shown in Table C.2 and used to calculate the B2 benefit. All of the accidents were used to develop the required fractions, regardless of whether or not they occurred at towered or non-towered airports, or might be judged "tower preventable." Implicit in the use of these figures, is the assumption that the fraction of occupants killed or injured in the tower-preventable accidents is approximately the same as the fraction killed or injured in the entire set of accidents in the six categories. The injury fractions for each aircraft type were obtained by calculating the fraction of occupants in each injury category in each accident, and then averaging over all of the accidents for that aircraft type.

Calculation of Confidence Limit

To construct a confidence interval for the difference in (mean) accident rates between non-towered and towered airports, we assume that the annual accident rates are normally distributed. The accident rate data (from Reference 9) are summarized in Table C.3. The 95 percent confidence interval for difference of the means is 2.7374 to 7.5946 accidents per million operations. Thus we are 95-percent confident that this interval contains the true difference in accident rates. The figure 7.5946 accidents per million operations is used in Section IV.B for tower discontinuance criteria.

Table C.1

Civil Aviation Accidents Occurring in U.S. Between 1964 and 1979 Used to Calculate Fatality, Injury and Damage Fractions

Accident Type	Air Carrier	Air Taxi	General Aviation
Wheels-up (excludes collapses due to equipment failure or malfunction)--NTSB accident Type C	23	164	2,727
Overshoot--NTSB accident type J	24	106	3,426
Undershoot--NTSB accident type K	31	65	2,249
Collided with object--NTSB accident type N	61	290	5,051
Improper compensation for wind conditions--NTSB cause/factor 64,65,66, 67-28, selected wrong runway relative to existing wind--NTSB cause/factor 64,65, 66, 67-80, and not aligned with runway--NTSB cause/factor 88-13	5	27	981
Accident Total	144	652	14,434

Table C.2

Fractions Derived from NTSB Data Used to Calculate B2 Benefit

	Air Carrier	Air Taxi	General Aviation	Military[a]
Fraction of Occupants with:				
Fatal Injuries	0.0871	0.0567	0.0329	0.0448
Serious Injuries	0.0337	0.0565	0.0497	0.0531
Minor Injuries	0.0504	0.0962	0.0992	0.0977
Fraction of Aircraft:				
Destroyed	0.1736	0.1273	0.1007	0.1140
Substantially Damaged	0.7917	0.8712	0.8962	0.8837

[a] Average of Air Taxi and General Aviation used for Military aircraft

Table C.3

Annual Tower Preventable Accident Rates[a]

Year	Accidents per Million Operations	
	Non-Towered	Towered
1	7.19	4.42
2	8.60	4.73
3	9.20	4.18
4	11.44	3.93
5	12.09	5.43
Mean	9.704	4.538

[a] From Reference 9

APPENDIX D. COMPUTER PROGRAM LISTINGS

This appendix provides listings for the FORTRAN computer program and subroutine TWRBEN used to develop the results in this report.

All of the variables used are defined in comment statements at the beginning of the FORTRAN programs. Coding lines 1650 thru 1670 of the main program may be used to select any records desired from the TAF file. In the listing provided, all non-towered airports are selected (by selecting TCODE = 0, no tower, or TCODE = 7, FAA tower candidate). To select just one site, for example PRC, Prescott, AZ, substitute the following coding for lines 1650 thru 1670:

```
DATA LOCI/'PRF '/
IF (LOCID.EQ.LOCI) GO TO 170
GO TO 160
```

For two sites use, for example,

```
DATA LOC1/'PSE '/, LOC2/'TNT '/
IF (LOCID.EQ.LOC1) GO TO 170
IF (LOCID.EQ.LOC2) GO TO 170
GO TO 160
```

To run the program for all locations in the TAF file simply delete coding lines 1650 thru 1670. As currently structured, FSCODE, the flight service station code, is only read <u>once</u> before reading the TAF file. Thus the same FSCODE will be used throughout the run. If one wishes to run a few locations with non-zero FSCODEs, they may be run together.

The format for the input file TAF may be found in Reference 13. The input Critical Value file format is described in Chapter IX.

Additional information concerning the use of these program may be obtained from FAA's Office of Aviation Policy and Plans.

```
C TOWER CRITERIA PROGRAM
C     FOR ESTABLISHMENT AND DISCONTINUANCE
C     PREPARED BY SUE HELZER, APO-230, UPDATED JANUARY 1983
C
C THIS PROGRAM READS THE INPUT FILES AND PASSES THE INFORMATION
C     TO TWRBEN WHICH COMPUTES THE BENEFITS.  THIS PROGRAM
C     CALCULATES THE COSTS, PRESENT VALUES AND B/C RATIOS.  IT
C     ALSO PRODUCES PRINTED OUTPUT, IF DESIRED, AND WRITES ONE
C     SUMMARY LINE TO FORTRAN FILE 14 FOR EACH SITE PROCESSED.
C
C VARIABLE LIST
C     CITY       NAME OF CITY - VECTOR WITH DIMENSION(7) FROM TAF
C     COSTA      ANNUAL COSTS TO OPERATE AND MAINTAIN TOWER
C     COSTD      INITIAL COST OF DISMANTLING TOWER, NEGATIVE VALUE
C     COSTE      INITIAL COST OF ESTABLISHING TOWER, POSITIVE VALUE
C     COST1      FIRST YEAR COST, USUALLY COSTE OR COSTD
C     CPV        CUMMULATIVE DISCOUNTED SUM OF ALL COSTS
C     CTOT       CUMMULATIVE SUM OF ALL COSTS
C     DIFD       DIFFERENCE BETWEEN DISCOUNTED BENEFITS AND COSTS
C     DIFT       DIFFERENCE BETWEEN TOTAL BENEFITS AND COSTS
C     DISC       DISCOUNT RATE, PERCENT
C   THE FOLLOWING FOUR FLAGS ARE INPUT BY USER FOR DESIRED PRINTOUT
C        FLAGB      IF FLAGB > OR = 0, TWRBEN WILL PRINT YEARLY BENEFITS
C        FLAGP      IF FLAGP > OR = 0, PRINT NORMAL CRITERIA OUTPUT
C        FLAGQ      IF FLAGQ > OR = 0, PRINT YEARLY AIRCRAFT OPERATIONS
C        FLAGV      IF FLAGV > OR = 0, PRINT CRITICAL VALUES
C     FSCODE     FLIGHT SERVICE STATION NEARBY CODE SET BY USER
C                FSCODE = OR < 0 MEANS NO FSS, INCLUDE OVERFLYING BENEFIT
C                IN B3 CALCULATION. IF > 0, EXCLUDE IT.
C     LO(I)      OCCUPANT LOAD, INCLUDING CREW, FOR AIRCRAFT TYPE I
C     LP(I)      PASSENGER LOAD, EXCLUDING CREW, FOR AIRCRAFT TYPE I
C     LOCID      LOCATION IDENTIFICATION CODE FROM TAF
C     NYR        NUMBER OF YEARS FOR BENEFIT/COST ANALYSIS, USUALLY 15
C     OPS(I,J)   OPERATIONS FOR TYPE I AIRCRAFT IN YEAR J FROM TAF
C     RATIOD     RATIO OF DISCOUNTED BENEFITS TO COSTS
C     RATIOT     RATIO OF TOTAL BENEFITS TO COSTS
C     REG        REGION CODE FROM TAF
C     ST         STATE CODE FROM TAF
C     TCODE      TOWER CODE OBTAINED FROM TAF FILE
C                TCODE = 1 OR 2 MEANS FAA TOWER, RUN DISCONTINUANCE
C                CRITERIA. IF TCODE IS NOT ONE, ESTABLISTHMENT IS RUN
C     VDM(I)     AVG VALUE OF SUBSTANTIAL DAMAGE TO AIRCRAFT TYPE I ($K)
C     VDS(I)     AVERAGE VALUE OF TYPE I AIRCRAFT DESTROYED ($K)
C     VF         VALUE OF FATAL INJURY ($K)
C     VO(I)      VARIABLE OPERATING COST FOR AIRCRAFT TYPE I ($/HOUR)
C     VM         VALUE OF MINOR INJURY ($K)
C     VS         VALUE OF SERIOUS INJURY ($K)
C     VT         VALUE OF TIME ($ PER HOUR)
C     YEAR       LOCAL VARIABLE INCREMENTED TO COMPUTE YEAR
C     YEAR1      FIRST YEAR OF OPERATION COUNTS USED
C INDICES
C     I          AIRCRAFT TYPE, SEE SUBROUTINE TWRBEN FOR LIST
```

```
                C     J         YEAR, J=1,NYR
                C     NIN       COUNTS RECORDS READ FROM TAF
                C     NOUT      COUNTS RECORDS OUTPUT TO FILE 14
                C     NSLECT    COUNTS RECORDS SELECTED FOR PROCESSING
                C
                C COMMON BLOCK VARIABLES RETURNED BY TWRBEN ARE DEFINED THERE
                C
                C     SET VARIABLE TYPES AND DIMENSIONS
                C     DEFINE COMMON
                C
0001                  REAL LO, LP
0002                  REAL*8 REG, ST
0003                  INTEGER FSCODE, TCODE, YEAR, YEAR1
                C
0004                  DIMENSION BC(4), BCD(4)
0005                  DIMENSION LO(7), LP(7), OPS(7,15), VDM(7), VDS(7), VO(7)
0006                  DIMENSION CITY(7)
                C
0007                  COMMON DISC, YEAR1, NYR, FLAGB, VF, VM, VS, VT, VDM, VDS, VO, LO,
                     1     LP, FOPEN, OPS, FSCODE, TCODE, PIR1, BPV, BTOT, BCD, BC,
                     2     IFTOT, IMTOT, ISTOT, A1TOT, A2TOT
                C
                C     INITIALIZE RECORD COUNTS AND SET DISCOUNT RATE
                C
0008                  NIN = 0
0009                  NSLECT = 0
0010                  NOUT = 0
0011                  DISC = 10.0
                C
                C     SET FIRST YEAR VALUE AND NUMBER OF YEARS FOR ANALYSIS
                C     READ FLAGS FOR PRINTOUT AND FSCODE
                C
0012                  YEAR1 = 1980
0013                  NYR = 15
0014                  READ (5,55) FLAGB, FLAGP, FLAGQ, FLAGV
0015            55    FORMAT (4F5.1)
0016                  READ (5,65) FSCODE
0017            65    FORMAT (I5)
                C
                C     READ CRITICAL VALUES FROM FILE
                C
0018                  READ (9,95) VF, VS, VM
0019                  READ (9,95) VT
0020                  READ (9,95) VDS
0021                  READ (9,95) VDM
0022                  READ (9,95) VO
0023                  READ (9,95) LO
0024                  READ (9,95) LP
0025                  READ (9,95) COSTA, COSTE, COSTD
0026                  READ (9,95) FOPEN
0027             95   FORMAT (50X,7F10.2)
                C
```

```
             C      PRINT CRITICAL VALUES IF FLAG SET
             C
 0028               IF (FLAGV.LT.0) GO TO 150
 0029                   WRITE (6,105)
 0030        105        FORMAT (1H1,////,41X, 'CRITICAL VALUES USED IN TOWER ',
                1           'CRITERIA',///)
 0031                   WRITE (6,115) VF, VS, VM
 0032        115        FORMAT (' FATALITY, SERIOUS INJURY, MINOR INJURY ($K)', 7X,
                1           3F11.2, /)
 0033                   WRITE (6,107) VT
 0034        107        FORMAT (' PASSENGER TIME ($ PER HOUR)', 23X, F11.2,//)
 0035                   WRITE (6,123)
 0036        123        FORMAT (58X, 'AC', 9X, 'AT', 9X, 'GAI', 8X, 'GAL', 8X, 'MI',
                1           9X, 'ML', //)
 0037                   WRITE (6,125) VDS
 0038        125        FORMAT (' DESTROYED AIRCRAFT REPLACEMENT COSTS ($K)', 9X,
                1           7F11.2, /)
 0039                   WRITE (6,127) VDM
 0040        127        FORMAT (' DAMAGED AIRCRAFT RESTORATION COSTS ($K)', 11X,
                1           7F11.2, /)
 0041                   WRITE (6,135) VO
 0042        135        FORMAT (' VARIABLE OPERATING COSTS ($ PER HOUR) ', 12X,
                1           7F11.2, /)
 0043                   WRITE (6,143) LO
 0044        143        FORMAT (' OCCUPANTS PER AIRCRAFT ', 27X, 7F11.2, /)
 0045                   WRITE (6,145) LP
 0046        145        FORMAT (' PASSENGERS PER AIRCRAFT ', 26X, 7F11.2, ///)
 0047                   WRITE (6,147) COSTA, COSTE, COSTD
 0048        147        FORMAT (' TOWER COSTS: ANNUAL, ESTABLISH, DISCONTINUE ($K)  ',
                1           3F11.2,///)
 0049                   WRITE (6,149) FOPEN
 0050        149        FORMAT (' PERCENT TOTAL OPS DURING PROPOSED OPERATING HOURS ',
                1           F11.2,///)
 0051        150    CONTINUE
             C
             C      CONVERT CRITICAL VALUE UNITS IF NECESSARY
             C      (PERCENT TO FRACTION)
             C
 0052               FOPEN = 0.01*FOPEN
             C
             C      READ INPUT DATA FROM TAF FILE AND INCREMENT INPUT COUNTER
             C
             C      IN FORMAT STATEMENT 165 FOLLOWING "19(90X)" USE
             C      "19X" TO START OPERATION COUNTS IN 1979
             C      "28X" TO START OPERATION COUNTS IN 1980
             C      "37X" TO START OPERATION COUNTS IN 1981
             C
 0053        160    READ (11,165,END=700) REG, ST, CITY, LOCID, TCODE,
                1       (OPS(1,J),J=1,15), (OPS(2,J),J=1,15),
                2       (OPS(3,J),J=1,15), (OPS(4,J),J=1,15), (OPS(5,J),J=1,15),
                3       (OPS(6,J),J=1,15)
 0054        165    FORMAT (2A5,6A4,A2,42X,A4,10X,I1,19(90X),28X,
```

```
                    1      6(45X,15F9.0))
 0055                    NIN = NIN + 1
                 C
                 C         THE FOLLOWING CODING FROM $$$$ TO $$$$ SHOULD BE MODIFIED
                 C         AS NECESSARY TO SELECT DESIRED RECORDS FROM TAF
                 C $$$$
                 C         CHOOSE SITES
                 C
 0056                      IF (TCODE.EQ.0) GO TO 170
 0057                      IF (TCODE.EQ.7) GO TO 170
 0058                      GO TO 160
                 C $$$$
                 C
                 C         INCREMENT SELECTED RECORD COUNTER
                 C         PRINT PAGE HEADINGS IF OUTPUT FLAGB OR FLAGQ IS SET
                 C
 0059            170       NSLECT = NSLECT + 1
 0060                      IF (FLAGB.GE.0.OR.FLAGQ.GE.0)
                    1          WRITE (6,175) LOCID, CITY, ST, REG, TCODE, FSCODE
 0061            175       FORMAT (1H1, 7A4, A2, 2A5, ' TCODE = ',I1, ', FSCODE = ', I1)
                 C
                 C         PRINT OUT OPERATION COUNTS IF REQUESTED AND SET SEVENTH
                 C         OPERATION CATEGORY, RESERVED FOR COMMUTER, TO ZERO
                 C
 0062                      IF (FLAGQ.LT.0) GO TO 190
 0063                          WRITE (6,185)
 0064            185           FORMAT (///,34X,'ANNUAL AIRCRAFT OPERATIONS BY CLASS',/)
 0065                          WRITE (6,187)
 0066            187           FORMAT ('  YEAR', 11X, 'AC', 13X, 'AT', 12X, 'GAI',
                    1              12X, 'GAL', 13X, 'MI', 13X, 'ML',/)
 0067            190       CONTINUE
                 C
 0068                      YEAR = YEAR1
 0069                      DO 200 J = 1,NYR
 0070                          OPS(7,J) = 0.0
 0071                          IF (FLAGQ.GE.0) WRITE (6,195) YEAR, (OPS(I,J),I=1,6)
 0072            195           FORMAT (I6, 6F15.0)
 0073                          YEAR = YEAR + 1
 0074            200       CONTINUE
                 C
                 C         SET COST FOR ESTABLISHMENT OR DISCONTINUANCE
                 C
 0075                      COST1 = COSTE
 0076                      IF (TCODE.EQ.1.OR.TCODE.EQ.2)
                    1          COST1 = COSTD
                 C
                 C         CALCULATE TOTAL AND DISCOUNTED COSTS
                 C
 0077                      CTOT = COST1 + NYR*COSTA
                 C
 0078                      CPV = COST1
 0079                      DO 300 J=1,NYR
```

```
0080                       CPV = CPV + COSTA/(1.0+0.01*DISC)**(J-0.5)
0081        300        CONTINUE
            C
            C          CALL TWRBEN TO CALCULATE BENEFITS FOR NYR YEARS
            C
0082                   CALL TWRBEN
            C
            C          LIST PAGE HEADING IF FLAGP IS SET
            C          IF ZERO BENEFITS, SKIP NORMAL OUTPUT, BRANCH TO PRINT MESSAGE
            C
0083                   IF (FLAGP.GE.0) WRITE (6,305) LOCID, CITY, ST, REG, TCODE,
                 1         FSCODE
0084        305        FORMAT (1H1, 20X, 'TOWER CRITERIA RESULTS FOR ', 7A4, A2,
                 1         2A5, ' TCODE = ', I1, ' ,FSCODE = ',I1)
            C
0085                   IF (BTOT.EQ.0.0.OR.BPV.EQ.0.0) GO TO 650
            C
            C          LIST PHASE I RATIO, BENEFIT VALUES, AND COSTS OBTAINED FROM
            C          TWRBEN IF FLAGP GREATER THAN OR = 0
            C
0086                   IF (FLAGP.LT.0) GO TO 500
0087                       WRITE (6,315) PIR1
0088        315            FORMAT (////,22X,'PHASE ONE RATIO FOR FIRST YEAR =',
                 1             F10.2, ///)
0089                       WRITE (6,323) NYR, YEAR1
0090        323            FORMAT (26X,'TOTAL CUMULATIVE TOWER BENEFITS AND COSTS ',
                 1             'FOR THE ',I2,' YEAR PERIOD BEGINING IN ', I4,/)
0091                       WRITE (6,325) DISC
0092        325            FORMAT (52X,'DISCOUNT RATE  = ', F5.1, ' PERCENT',//)
0093                       WRITE (6,335)
0094        335            FORMAT (35X,'BENEFIT CATEGORY', 27X, 'NOT DISCOUNTED', 8X,
                 1             'DISCOUNTED')
0095                       WRITE (6,337)
0096        337            FORMAT (83X, '($K)', 15X, '($K)',/)
0097                       WRITE (6,345) BC(1), BCD(1)
0098        345            FORMAT (25X,'B1     PREVENTED COLLISIONS', 17X,
                 1             2F19.0, /)
0099                       WRITE (6,355) BC(2), BCD(2)
0100        355            FORMAT (25X,'B2     OTHER PREVENTABLE ACCIDENTS', 10X,
                 1             2F19.0, /)
0101                       WRITE (6,365) BC(3),BCD(3)
0102        365            FORMAT (25X, 'B3     ADDITIONAL FLYING AVOIDED', 12X,
                 1             2F19.0,/)
0103                       WRITE (6,375) BC(4),BCD(4)
0104        375            FORMAT (25X,'B4     OTHER TOWER BENEFITS ',16X,
                 1             2F19.0, //)
0105                       WRITE (6,385) BTOT, BPV
0106        385            FORMAT (32X, 'TOTAL TOWER BENEFITS', 17X, 2F19.0, //)
0107                       WRITE (6,405) CTOT, CPV
0108        405            FORMAT(32X, 'TOTAL TOWER COSTS', 20X, 2F19.0, //)
0109        500        CONTINUE
            C
```

```
            C         CALCULATE BENEFIT-COST RATIOS AND DIFFERENCES
            C
 0110                 DIFT = BTOT - CTOT
 0111                 DIFD = BPV - CPV
 0112                 IF (CTOT.LE.0.OR.CPV.LE.0) GO TO 600
 0113                     RATIOT = BTOT/CTOT
 0114                     RATIOD = BPV/CPV
            C
            C             PRINT DIFFERENCES AND RATIOS IF FLAGP > OR = 0
            C
 0115                     IF (FLAGP.LT.0) GO TO 580
 0116                         WRITE (6,505) DIFT, DIFD
 0117       505               FORMAT (32X,'TOTAL TOWER BENEFITS MINUS COSTS', 5X,
                1                 2F19.0,//)
 0118                         WRITE (6,515) RATIOT, RATIOD
 0119       515               FORMAT (32X, 'RATIO: TOWER BENEFITS/COSTS', 10X,
                1                 2F19.2,///)
 0120                         WRITE (6,555) NYR, IFTOT, ISTOT, IMTOT
 0121       555               FORMAT (22X, 'FATAL, SERIOUS, MINOR INJURIES FOR ',I2,
                1                   ' YEARS', 3F14.2,//)
 0122                         WRITE (6,565) NYR, A1TOT, A2TOT
 0123       565               FORMAT (22X,'COLLISIONS, OTHER ACCIDENTS FOR ',I2 ,
                1                   ' YEARS', 3X, 2F14.2,//)
 0124       580           CONTINUE
 0125       600       CONTINUE
            C
            C         INCREMENT OUTPUT RECORD COUNTER
            C         WRITE LINE TO FILE FOR EACH SITE PROCESSED
            C
 0126       610       NOUT = NOUT + 1
 0127                 WRITE (14,615) LOCID, CITY, ST, REG, TCODE, PIR1, RATIOD, DIFD
 0128       615       FORMAT (7A4, A2, 1X, 2A5, I1, 2F8.2, F8.0)
            C
            C     GO GET NEXT RECORD
            C
 0129             GO TO 160
            C
            C     BRANCH POINT FOR ZERO BENEFITS
            C
            C     PRINT LINE IF FLAGP GREATER OR EQUAL 0
            C     SET VALUES OUTPUT TO FILE 14
            C     BRANCH TO WRITE TO OUTPUT FILE
            C
 0130       650   IF (FLAGP.GE.0) WRITE (6,655) LOCID, CITY, ST, REG, TCODE
 0131       655   FORMAT (1H0,/, ' *** NO OPERATIONS OR NO BENEFITS FOR ', 7A4,
                1      A2, 1X, 2A5, I1,' ***', //)
            C
 0132             PIR1 = 0
 0133             RATIOD = 0
 0134             DIFD = -CPV
            C
 0135             GO TO 610
```

```
                 C                                                            00003130
                 C      END OF PROCESSING - LIST RECORD COUNTS                00003140
                 C                                                            00003150
 0136            700    WRITE (6,705) NIN                                     00003160
 0137                   WRITE (6,710) NSLECT                                  00003170
 0138                   WRITE (6,715) NOUT                                    00003180
 0139            705    FORMAT ('1NUMBER OF TAF INPUT RECORDS READ = ', I5)   00003190
 0140            710    FORMAT ('0NUMBER OF RECORDS SELECTED AND PROCESSED = ', I5)  00003200
 0141            715    FORMAT ('0NUMBER OF RECORDS OUTPUT TO FILE 14 = ', I5)  00003210
 0142                   STOP                                                  00003220
 0143                   END                                                   00003230
```

```
0001          SUBROUTINE TWRBEN
        C      THIS SUBROUTINE COMPUTES BENEFITS OF AN AIR TRAFFIC CONTROL
        C      TOWER FOR A FIFTEEN YEAR PERIOD BEGINING IN YEAR1.
        C      INPUT IS FOUND IN THE COMMON BLOCK VARIABLES
        C      DISC, YEAR1, FLAGB, VF, VM, VS, VT, VDM, VDS, VO,
        C      LO, LP, OPS, FSCODE, TCODE.
        C      OUTPUT IS STORED IN COMMON BLOCK VARIABLES
        C      PIR1, BPV, BTOT, BCD, ,BC, IFTOT,IMTOT, ISTOT, A1TOT, A2TOT.
        C      ALL VARIABLES ARE DEFINED AND DIMENSIONED BELOW.
        C      IF FLAGB > OR = 0, ANNUAL BENEFITS FOR THE FIFTEEN YEAR PERIOD
        C      ARE PRINTED.
        C
        C  VARIABLE LIST
        C      A1         NUMBER OF COLLISIONS ANNUALLY
        C      A1TOT      CUMMULATIVE TOTAL OF COLLISIONS
        C      A2         NUMBER OF OTHER TOWER PREVENTABLE ACCIDENTS ANNUALLY
        C      A2TOT      CUMMULATIVE TOTAL OF OTHER TOWER PREVENTABLE ACCIDENTS
        C      B(K)       BENEFIT CATEGORIES
        C      BC(K)      CUMMULATIVE SUM OF BENEFIT CATEGORIES, B(K)
        C      BCD(K)     CUMMULATIVE DISCOUNTED SUM OF BENEFIT CATEGORIES
        C      BPV        CUMMULATIVE DISCOUNTED SUM OF TOTAL BENEFIT BT
        C      BT         TOTAL BENEFIT FOR ONE YEAR J: B(1)+B(2)+B(3)+B(4)
        C      BTOT       CUMMULATIVE SUM OF TOTAL BENEFIT BT
        C    CONSTANT COLLISION FRACTIONS USED TO CALCULATE B(1)
        C         CADM       AIRBORNE COLLISION - SUBSTANTIAL DAMAGE FRACTION
        C         CADS       AIRBORNE COLLISION - FRACTION DESTROYED
        C         CAIF       AIRBORNE COLLISION - FATAL INJURY FRACTION
        C         CAIM       AIRBORNE COLLISION - MINOR INJURY FRACTION
        C         CAIS       AIRBORNE COLLISION - SERIOUS INJURY FRACTION
        C         CGDM       GROUND-TO-GROUND COLLISION - SUBSTANTIAL DAMAGE
        C         CGDS       GROUND-TO-GROUND COLLISION - FRACTION DESTROYED
        C         CGIF       GROUND-TO-GROUND COLLISION - FATAL INJURY
        C         CGIM       GROUND-TO-GROUND COLLISION - MINOR INJURY
        C         CGIS       GROUND-TO-GROUND COLLISION - SERIOUS INJURY
        C      DISC       DISCOUNT RATE, PERCENT
        C      DM1        DOLLAR VALUE OF SUBSTANTIALLY DAMAGED AIRCRAFT FOR B(1)
        C      DM2        DOLLAR VALUE OF SUBSTANTIALLY DAMAGED AIRCRAFT FOR B(2)
        C      DS1        DOLLAR VALUE OF DESTROYED AIRCRAFT FOR B(1)
        C      DS2        DOLLAR VALUE OF DESTROYED AIRCRAFT FOR B(2)
        C    CONSTANT ACCIDENT FRACTIONS USED TO CALCULATE B(2)
        C         FDM2(I)    FRACTION AIRCRAFT WITH SUBSTANTIAL DAMAGE
        C         FDS2(I)    FRACTION AIRCRAFT DESTROYED
        C         FIF2(I)    FRACTION OCCUPANTS RECEIVING FATAL INJURY
        C         FIM2(I)    FRACTION OCCUPANTS RECEIVING MINOR INJURY
        C         FIS2(I)    FRACTION OCCUPANTS RECEIVING SERIOUS INJURY
        C      FLAGB      IF FLAGB > OR = 0, PRINT ANNUAL BENEFITS
        C      FOPEN      FRACTION OF OPERATIONS OCCURING WHEN TOWER IS OPEN
        C      FSCODE     FLIGHT SERVICE STATION NEARBY CODE SET BY USER
        C                 FSCODE = OR < 0 MEANS NO FSS, INCLUDE OVERFLYING
        C                 BENEFIT IN B3 CALCULATION. IF > 0, EXCLUDE IT.
        C      IF1        FATAL INJURIES ASSOCIATED WITH B(1)
        C      IF2        FATAL INJURIES ASSOCIATED WITH B(2)
```

```
C      IFTOT     CUMMULATIVE SUM OF ALL FATAL INJURIES                  00003760
C      IM1       MINOR INJURIES ASSOCIATED WITH B(1)                    00003770
C      IM2       MINOR INJURIES ASSOCIATED WITH B(2)                    00003780
C      IMTOT     CUMMULATIVE SUM OF ALL MINOR INJURIES                  00003790
C      IS1       SERIOUS INJURIES ASSOCIATED WITH B(1)                  00003800
C      IS2       SERIOUS INJURIES ASSOCIATED WITH B(2)                  00003810
C      ISTOT     CUMMULATIVE SUM OF ALL SERIOUS INJURIES                00003820
C      LO(I)     OCCUPANT LOAD, INCLUDING CREW, FOR AIRCRAFT TYPE I     00003830
C      LP(I)     PASSENGER LOAD, EXCLUDING CREW, FOR AIRCRAFT TYPE I    00003840
C      NYR       NUMBER OF YEARS FOR BENEFIT/COST ANALYSIS, USUALLY 15  00003850
C      OPS(I,J)  NUMBER OF OPERATIONS FOR AIRCRAFT TYPE I IN YEAR J     00003860
C      OPSALL    TOTAL OPERATIONS FOR ONE YEAR J (IN MILLIONS)          00003870
C      OPSM(I)   OPS(I,J) IN MILLIONS FOR FIXED J                       00003880
C      OTHER     FRACTION OF B(1)+B(2)+B(3) APPLIED TO OTHER BENEFITS   00003890
C      P(I)      PHASE I RATIO DENOMINATORS                             00003900
C      PD(I)     PHASE I DENOMINATORS FOR DISCONTINUANCE                00003910
C      PE(I)     PHASE I DENOMINATORS FOR ESTABLISHMENT                 00003920
C      PIR       PHASE I RATIO                                          00003930
C      PIR1      PHASE I RATIO FOR FIRST YEAR                           00003940
C      RCA       AIRBORNE COLLISION CONSTANT USED FOR B(1)              00003950
C      RCAD      RCA FOR DISCONTINUANCE CRITERIA                        00003960
C      RCAE      RCA FOR ESTABLISHMENT CRITERIA                         00003970
C      RCG       GROUND-TO-GROUND COLLISION CONSTANT USED FOR B(1)      00003980
C      RCGD      RCG FOR DISCONTINUANCE CRITERIA                        00003990
C      RCGE      RCG FOR ESTABLISHMENT CRITERIA                         00004000
C      R2(I)     RATE OF OTHER PREVENTABLE ACCIDENTS USED FOR B(2)      00004010
C      R2D(I)    R2(I) FOR DISCONTINUANCE CRITERIA                      00004020
C      R2E(I)    R2(I) FOR ESTABLISHMENT CRITERIA                       00004030
C      TCODE     TOWER CODE: IF 1 OR 2, PROGRAM RUNS DISCONTINUANCE     00004040
C                CRITERIA. IF TCODE IS NOT 1 OR 2, ESTABLISHMENT IS RUN.00004050
C      TIME      ADDITIONAL FLYING TIME PER OPERATION FOR B3 (HOURS)    00004060
C      TIME1     TIME FOR NO FSS, FSCODE < OR = 0                       00004070
C      TIME2     TIME FOR NEARBY FSS, FSCODE > 0                        00004080
C      VDM(I)    AVG VALUE OF SUBSTANTIAL DAMAGE TO AIRCRAFT TYPE I ($K)00004090
C      VDS(I)    AVERAGE VALUE OF TYPE I AIRCRAFT DESTROYED ($K)        00004100
C      VHR(I)    AVERAGE VALUE OF ONE HOUR OF FLYING AIRCRAFT I ($K)    00004110
C      VF        VALUE OF FATAL INJURY ($K)                             00004120
C      VO(I)     VARIABLE OPERATING COST FOR AIRCRAFT TYPE I ($ / HOUR) 00004130
C      VM        VALUE OF MINOR INJURY ($K)                             00004140
C      VS        VALUE OF SERIOUS INJURY ($K)                           00004150
C      VT        VALUE OF TIME ($ PER HOUR)                             00004160
C      YEAR      LOCAL VARIABLE INCREMENTED TO COMPUTE BENEFIT YEAR     00004170
C      YEAR1     FIRST YEAR OF OPERATION COUNTS USED                    00004180
C    INDICES                                                            00004190
C      I      AIRCRAFT TYPE                                             00004200
C                1 AIR CARRIER                                          00004210
C                2 AIR TAXI - INCLUDING COMMUTER                        00004220
C                3 GENERAL AVIATION, ITENERANT                          00004230
C                4 GENERAL AVIATION, LOCAL                              00004240
C                5 MILITARY, ITENERANT                                  00004250
C                6 MILITARY, LOCAL                                      00004260
C                7 NOT USED, SAVED FOR COMMUTER CATEGORY                00004270
```

```
              C     J      YEAR, J=1,NYR
              C     K      BENEFIT CATEGORY, K=1,4
              C               1 FEWER COLLISIONS BETWEEN AIRCRAFT
              C               2 OTHER TOWER PREVENTABLE ACCIDENT BENEFITS
              C               3 ADDITIONAL FLYING AVOIDED
              C               4 OTHER BENEFITS
              C
              C     SET VARIABLE TYPES
              C     SET VARIABLE DIMENSIONS
              C     DEFINE COMMON
              C
0002                INTEGER FSCODE, TCODE, YEAR, YEAR1
0003                REAL IF1, IF2, IFTOT, IM1, IM2, IMTUT, IS1, IS2, ISTOT,  LO, LP
              C
0004                DIMENSION B(4), BC(4), BCD(4)
0005                DIMENSION FDM2(7), FDS2(7)
0006                DIMENSION FIF2(7), FIM2(7), FIS2(7)
0007                DIMENSION LO(7), LP(7)
0008                DIMENSION OPS(7,15), OPSM(7)
0009                DIMENSION P(7), PD(7), PE(7)
0010                DIMENSION R2(7), R2D(7), R2E(7)
0011                DIMENSION VDM(7), VDS(7), VHR(7), VO(7)
              C
0012                COMMON DISC, YEAR1, NYR, FLAGB, VF, VM, VS, VT, VDM, VDS, VO, LO,
                   1     LP, FOPEN, OPS, FSCODE, TCODE, PIR1, BPV, BTOT, BCD, BC,
                   2     IFTOT, IMTOT, ISTOT, A1TOT, A2TOT
              C
              C     SET FIXED CONSTANTS
              C
0013                DATA CADM/0.526/, CADS/0.347/
0014                DATA CAIF/0.210/, CAIM/0.064/, CAIS/0.079/
0015                DATA CGDM/0.740/, CGDS/0.096/
0016                DATA CGIF/0.047/, CGIM/0.004/, CGIS/0.011/
0017                DATA FDM2/0.7917,0.8712,2*0.8962,2*0.8837,0.0/
0018                DATA FDS2/0.1736,0.1273,2*0.1007,2*0.1140,0.0/
0019                DATA FIF2/0.0871,0.0567,2*0.0329,2*0.0448,0.0/
0020                DATA FIM2/0.0504,0.0962,2*0.0992,2*0.0977,0.0/
0021                DATA FIS2/0.0337,0.0565,2*0.0497,2*0.0531,0.0/
0022                DATA OTHER/0.0/
0023                DATA PE/38000.,90000.,160000.,280000.,48000.,90000.,1./
0024                DATA PD/15000.,40000.,75000.,125000.,20000.,35000.,1./
0025                DATA RCAD/10.51/, RCGD/6.95/, R2D/3.798,6*7.595/
0026                DATA RCAE/4.672/, RCGE/2.012/,R2E/2.583,6*5.166/
0027                DATA TIME1/0.00633/, TIME2/0.00417/
              C
              C     CALCULATE TOTAL VALUE OF FLYING FOR ONE HOUR ($K)
              C
              C     SET PHASE I RATIO DENOMINATORS
              C     SET ACCIDENT RATE CONSTANTS FOR ESTABLISHMENT OR DISCONTINUANCE
              C
0028                DO 70 I = 1,7
0029                   VHR(I) = 0.001*(LP(I)*VT + VO(I))
```

```
      C
                IF (TCODE.EQ.1.OR.TCODE.EQ.2) GO TO 50
                    P(I) = PE(I)
                    R2(I) = R2E(I)
                GO TO 60
      50        CONTINUE
                    P(I) = PD(I)
                    R2(I) = R2D(I)
      60        CONTINUE
      70    CONTINUE
      C
            IF (TCODE.EQ.1.OR.TCODE.EQ.2) GO TO 80
                RCA = RCAE
                RCG = RCGE
            GO TO 90
      80    CONTINUE
                RCA = RCAD
                RCG = RCGD
      90    CONTINUE
      C
      C     CALCULATE BENEFITS FOR NYR PERIOD
      C     CALCULATE DISCOUNTED AND NON-DISCOUNTED TOTALS OVER TIME
      C     ALL BENEFITS ARE CALCULATED IN TERMS OF THOUSANDS OF DOLLARS ($K)
      C
      C     INITILIZE VARIABLES
      C
            A1TOT = 0.0
            A2TOT = 0.0
            DO 120 K = 1,4
                BC(K) = 0
                BCD(K) = 0
      120   CONTINUE
            BPV = 0.0
            BTOT = 0.0
            IFTOT = 0.0
            IMTOT = 0.0
            ISTOT = 0.0
            YEAR = YEAR1
      C
      C     IF FLAGB IS SET TO PRINT ANNUAL BENEFITS, PRINT PAGE HEADINGS
      C
            IF(FLAGB.LT.0) GO TO 200
                WRITE (6,155)
      155       FORMAT (////,56X,'ANNUAL TOWER BENEFITS ($K)',/)
                WRITE (6,165)
      165       FORMAT (10X,'PHASE I',18X,'BENEFIT CATEGORIES',18X,'TOTAL',
           1        20X,'CUMULATIVE')
                IF(FLAGB.GE.0) WRITE (6,175)
      175       FORMAT ('  YEAR',5X,'RATIO',9X,'B1',10X,'B2',10X,'B3',10X,
           1        'B4', 7X,'FOR YEAR', 6X,'NOT DISCOUNTED', 6X,
           2        'DISCOUNTED',/)
      200     CONTINUE
```

```
                C
                C     ENTER DO LOOP TO CALCULATE BENEFITS FOR EACH YEAR AND
                C     CUMMULATIVE SUMS
                C
 0067                 DO 300 J = 1,NYR
                C
                C        CALCULATE PHASE I RATIO FOR YEAR J
                C        CHANGE OPERATION COUNT UNITS TO MILLIONS OF OPERATIONS
                C        CALCULATE ALL OPERATIONS IN YEAR J, OPSALL, IN MILLIONS
                C        SAVE FIRST YEAR PHASE I RATIO
                C
 0068                    OPSALL = 0.0
 0069                    PIR = 0.0
 0070                    DO 220 I = 1,7
 0071                       PIR = PIR + OPS(I,J)/P(I)
 0072                       OPSM(I) = 0.000001*OPS(I,J)
 0073                       OPSALL = OPSALL + OPSM(I)
 0074           220      CONTINUE
                C
 0075                    IF (J.EQ.1) PIR1 = PIR
                C
                C        CALCULATE B(1), B(2) FOR YEAR J
                C
                C        INITIALIZE VARIABLES
 0076                    IF1 = 0.0
 0077                    IM1 = 0.0
 0078                    IS1 = 0.0
 0079                    DM1 = 0.0
 0080                    DS1 = 0.0
 0081                    IF2 = 0.0
 0082                    IM2 = 0.0
 0083                    IS2 = 0.0
 0084                    DM2 = 0.0
 0085                    DS2 = 0.0
 0086                    A2 = 0.0
                C        SUM ON AIRCRAFT TYPE
 0087                    DO 230 I = 1,7
 0088                       IF1 = IF1 + 2*(RCA*CAIF + RCG*CGIF)*OPSM(I)*OPSALL*LO(I)
 0089                       IM1 = IM1 + 2*(RCA*CAIM + RCG*CGIM)*OPSM(I)*OPSALL*LO(I)
 0090                       IS1 = IS1 + 2*(RCA*CAIS + RCG*CGIS)*OPSM(I)*OPSALL*LO(I)
 0091                       DM1 = DM1 + 2*(RCA*CADM + RCG*CGDM)*OPSM(I)*OPSALL*VDM(I)
 0092                       DS1 = DS1 + 2*(RCA*CADS + RCG*CGDS)*OPSM(I)*OPSALL*VDS(I)
 0093                       IF2 = IF2 + R2(I)*OPSM(I)*FIF2(I)*LO(I)
 0094                       IM2 = IM2 + R2(I)*OPSM(I)*FIM2(I)*LO(I)
 0095                       IS2 = IS2 + R2(I)*OPSM(I)*FIS2(I)*LO(I)
 0096                       DM2 = DM2 + R2(I)*OPSM(I)*FDM2(I)*VDM(I)
 0097                       DS2 = DS2 + R2(I)*OPSM(I)*FDS2(I)*VDS(I)
 0098                       A2 = A2 + R2(I)*OPSM(I)
 0099           230      CONTINUE
                C        CALCULATE A1 AND DOLLAR VALUES FOR B(1) AND B(2) IN $K
 0100                    A1 = (RCA + RCG)*(OPSALL**2)
 0101                    B(1) = IF1*VF + IM1*VM + IS1*VS + DM1 + DS1
```

```
0102                 B(2) = IF2*VF + IM2*VM + IS2*VS + DM2 + DS2
              C
              C      CALCULATE B(3) FOR YEAR J
              C
0103                 IF (FSCODE.LE.0) TIME = TIME1
0104                 IF (FSCODE.GT.0) TIME = TIME2
0105                 B(3) = TIME*(OPS(2,J)*VHR(2) + OPS(3,J)*VHR(3)
                 1        + OPS(5,J)*VHR(5))
              C
              C      CALCULATE B(4) FOR YEAR J
              C
0106                 B(4) = OTHER*(B(1) + B(2) + B(3))
              C
              C      IF DISCONTINUANCE CRITERIA BRANCH TO CALCULATE TOTAL BENEFIT
              C
0107                 IF (TCODE.EQ.1.OR.TCODE.EQ.2) GO TO 250
              C
              C      IF ESTABLISHMENT CRITERIA, ADJUST RESULTS FOR FRACTION OF
              C      OPERATIONS WHICH OCCUR WHEN TOWER IS OPEN
              C
0108                     DO 240 I = 1,4
              C
0109                         B(I) = FOPEN*B(I)
0110          240        CONTINUE
0111                     A1 = FOPEN*A1
0112                     A2 = FOPEN*A2
0113                     IF1 = FOPEN*IF1
0114                     IF2 = FOPEN*IF2
0115                     IM1 = FOPEN*IM1
0116                     IM2 = FOPEN*IM2
0117                     IS1 = FOPEN*IS1
0118                     IS2 = FOPEN*IS2
              C
              C      CALCULATE TOTAL BENEFIT FOR YEAR J
              C
0119          250    BT = B(1) + B(2) + B(3) + B(4)
              C
              C      CALCULATE CUMMULATIVE SUMS OF ACCIDENTS, BENEFITS AND INJURIES
              C
0120                 A1TOT = A1TOT + A1
0121                 A2TOT = A2TOT + A2
0122                 DO 260 K = 1,4
0123                     BC(K) = BC(K) + B(K)
0124                     BCD(K) = BCD(K) + B(K)/(1.0 + 0.01*DISC)**(J-0.5)
0125          260    CONTINUE
0126                 BPV = BPV + BT/(1.0 + 0.01*DISC)**(J-0.5)
0127                 BTOT = BTOT + BT
0128                 IFTOT = IFTOT + IF1 + IF2
0129                 IMTOT = IMTOT + IM1 + IM2
0130                 ISTOT = ISTOT + IS1 + IS2
              C
              C      PRINT OUT YEARLY BENEFITS IF FLAGP IS SET
```

```
              C
0131                 IF(FLAGB.GE.0) WRITE (6,275) YEAR, PIR, B, BT, BTOT, BPV
0132          275    FORMAT(I6, F10.2, 5F12.0, 2F18.0)
              C
              C      INCREMENT YEAR
              C      CONTINUE DO LOOP
              C
0133                 YEAR = YEAR + 1
0134          300  CONTINUE
              C
              C    RETURN CONTROL TO MAIN PROGRAM
              C
0135               RETURN
0136               END
```

APPENDIX E. ADDITIONAL CRITERIA RESULTS

Table E.1 shows the results of applying new tower establishment criteria to the 220 locations with benefit/cost ratio larger than 0.25. The locations are given alphabetically by region, state and city. Since these results were obtained in the same way as the results presented in Chapter V, the comments at the beginning of that Chapter apply here also.

Table E.2 shows the results of applying the new tower discontinuance criteria to the 432 locations with FAA towers, also sorted by region, state, and city.

The tower codes, TCODE, used are

0	no tower
1	FAA tower
7	candidate for FAA tower

TABLE E.1 (PAGE 1)

NEW ESTABLISHMENT CRITERIA RESULTS
LOCATIONS WITH BENEFIT/COST RATIO > OR = 0.25

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
FRN	ANCHORAGE/FT RICHARDSO	AK	AAL	0	0.95	0.93	-220.
BET	BETHEL	AK	AAL	7	1.35	1.92	2929.
BTT	BETTLES	AK	AAL	0	0.33	0.26	-2353.
BIG	DELTA JUNCTION/FT GREE	AK	AAL	0	0.44	0.40	-1905.
DLG	DILLINGHAM	AK	AAL	7	0.48	0.46	-1721.
FBK	FAIRBANKS/FT WAINWRIGH	AK	AAL	0	0.98	0.96	-117.
FYU	FORT YUKON	AK	AAL	0	0.30	0.28	-2283.
HOM	HOMER	AK	AAL	0	0.30	0.25	-2382.
5KE	KETCHIKAN	AK	AAL	0	0.89	1.19	593.
OTZ	KOTZEBUE	AK	AAL	7	0.69	0.74	-828.
MCG	MCGRATH	AK	AAL	0	0.66	0.61	-1237.
5NK	NAKNEK	AK	AAL	0	0.42	0.37	-1986.
OME	NOME	AK	AAL	0	0.42	0.41	-1858.
PAQ	PALMER	AK	AAL	0	0.40	0.33	-2118.
SIT	SITKA	AK	AAL	0	0.30	0.26	-2345.
SXQ	SOLDOTNA	AK	AAL	0	0.36	0.25	-2367.
WSN	SOUTH NAKNEK	AK	AAL	0	0.40	0.36	-2024.
AMW	AMES	IA	ACE	0	0.46	0.31	-2183.
CBF	COUNCIL BLUFFS	IA	ACE	0	0.47	0.29	-2250.
DDC	DODGE CITY	KS	ACE	0	0.37	0.30	-2223.
GCK	GARDEN CITY	KS	ACE	0	0.29	0.31	-2191.
GBD	GREAT BEND	KS	ACE	0	0.36	0.30	-2219.
3LA	LAWRENCE	KS	ACE	0	0.37	0.29	-2245.
LBL	LIBERAL	KS	ACE	0	0.40	0.41	-1870.
MHK	MANHATTAN	KS	ACE	0	0.46	0.42	-1839.
3GV	GRAIN VALLEY	MO	ACE	0	0.51	0.34	-2095.
K84	LEES SUMMIT	MO	ACE	0	0.39	0.51	-1543.
3WE	ST LOUIS	MO	ACE	0	0.54	0.58	-1329.
LBF	NORTH PLATTE	NE	ACE	0	0.31	0.25	-2367.
MLE	OMAHA	NE	ACE	0	0.47	0.47	-1685.
BFF	SCOTTSBLUFF	NE	ACE	0	0.30	0.26	-2334.
ESN	EASTON	MD	AEA	0	0.36	0.25	-2364.
FDK	FREDERICK	MD	AEA	0	0.45	0.26	-2360.
GAI	GAITHERSBURG	MD	AEA	0	0.57	0.41	-1868.
SBY	SALISBURY	MD	AEA	0	0.58	0.44	-1790.
BLM	BELMAR-FARMINGDALE	NJ	AEA	0	1.14	1.12	375.
16N	BERLIN	NJ	AEA	0	0.49	0.29	-2234.
LDJ	LINDEN	NJ	AEA	0	0.51	0.42	-1851.
MIV	MILLVILLE	NJ	AEA	0	0.42	0.25	-2372.
7MY	MOUNT HOLLY	NJ	AEA	0	0.71	0.52	-1523.
N87	ROBBINSVILLE	NJ	AEA	0	1.40	1.42	1343.
N52	SOMERVILLE	NJ	AEA	0	0.53	0.33	-2107.
N63	SUSSEX	NJ	AEA	0	0.46	0.25	-2374.
WWD	WILDWOOD	NJ	AEA	0	0.41	0.26	-2349.
3G8	BATAVIA	NY	AEA	0	0.51	0.31	-2174.
D35	BUFFALO	NY	AEA	0	0.48	0.35	-2045.
DKK	DUNKIRK	NY	AEA	0	0.43	0.27	-2320.
N17	ENDICOTT	NY	AEA	0	0.62	0.37	-1984.
MGJ	MONTGOMERY	NY	AEA	0	0.49	0.31	-2185.
FLU	NEW YORK/FLUSHING/	NY	AEA	0	0.44	0.28	-2293.

TABLE E.1 (PAGE 2)

NEW ESTABLISHMENT CRITERIA RESULTS
LOCATIONS WITH BENEFIT/COST RATIO > OR = 0.25

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
1N1	SHIRLEY	NY	AEA	0	0.77	0.55	-1441.
N24	SPRING VALLEY	NY	AEA	0	0.67	0.46	-1701.
BTP	BUTLER	PA	AEA	0	0.46	0.26	-2331.
40N	COATESVILLE	PA	AEA	0	0.47	0.25	-2388.
N25	DOWNINGTOWN	PA	AEA	0	0.57	0.37	-1983.
G08	MONONGAHELA	PA	AEA	0	0.73	0.53	-1489.
N67	PHILADELPHIA	PA	AEA	0	0.64	0.55	-1428.
N34	PROSPECTVILLE	PA	AEA	0	0.56	0.36	-2038.
3G2	WASHINGTON	PA	AEA	0	0.41	0.28	-2289.
W09	LEESBURG	VA	AEA	0	0.47	0.34	-2078.
W10	MANASSAS	VA	AEA	0	0.57	0.65	-1102.
PVG	PORTSMOUTH	VA	AEA	0	0.39	0.26	-2357.
JOT	JOLIET	IL	AGL	0	0.44	0.27	-2318.
1C5	PLAINFIELD	IL	AGL	0	0.56	0.38	-1962.
UIN	QUINCY	IL	AGL	0	0.39	0.29	-2260.
LOT	ROMBOVILLE	IL	AGL	0	0.77	0.56	-1391.
UGN	WAUKEGAN	IL	AGL	0	0.92	0.76	-775.
OKK	KOKOMO	IN	AGL	0	0.37	0.28	-2291.
2G5	DETROIT/GROSSE ILE	MI	AGL	0	0.51	0.29	-2241.
4D0	GRAND LEDGE	MI	AGL	0	0.53	0.48	-1644.
MQT	MARQUETTE	MI	AGL	0	0.38	0.26	-2353.
D97	SOUTH ST PAUL	MN	AGL	0	0.42	0.25	-2362.
21D	ST PAUL	MN	AGL	0	0.64	0.45	-1742.
MGY	DAYTON	OH	AGL	0	0.48	0.33	-2124.
HAO	HAMILTON	OH	AGL	0	0.47	0.33	-2137.
22G	LORAIN/ELYRIA/	OH	AGL	0	0.70	0.52	-1519.
PCW	PORT CLINTON	OH	AGL	0	0.36	0.31	-2181.
ABR	ABERDEEN	SD	AGL	0	0.51	0.43	-1806.
PIR	PIERRE	SD	AGL	0	0.41	0.34	-2091.
ATY	WATERTOWN	SD	AGL	0	0.41	0.34	-2100.
EAU	EAU CLAIRE	WI	AGL	0	0.42	0.35	-2069.
ENW	KENOSHA	WI	AGL	0	0.57	0.41	-1865.
CWA	MOSINEE	WI	AGL	0	0.40	0.36	-2042.
ETB	WEST BEND	WI	AGL	0	0.79	0.71	-917.
OXC	OXFORD	CT	ANE	0	0.60	0.44	-1777.
FIT	FITCHBURG	MA	ANE	0	0.45	0.34	-2103.
PYM	PLYMOUTH	MA	ANE	0	0.43	0.25	-2375.
6B6	STOW	MA	ANE	0	0.52	0.35	-2069.
AUG	AUGUSTA	ME	ANE	0	0.55	0.30	-2215.
WVL	WATERVILLE	ME	ANE	0	0.31	0.25	-2383.
CON	CONCORD	NH	ANE	0	0.36	0.26	-2341.
ASH	NASHUA	NH	ANE	0	0.39	0.27	-2316.
99B	NORTH KINGSTOWN	RI	ANE	0	0.35	0.25	-2373.
SFZ	SMITHFIELD	RI	ANE	0	0.44	0.28	-2270.
01V	AURORA	CO	ANM	0	0.40	0.25	-2387.
DRO	DURANGO	CO	ANM	0	0.49	0.43	-1791.
48V	ERIE	CO	ANM	0	0.51	0.36	-2017.
3V5	FORT COLLINS	CO	ANM	0	0.42	0.29	-2260.
FNL	FORT COLLINS/LOVELAND/	CO	ANM	0	0.63	0.52	-1520.
GXY	GREELEY	CO	ANM	7	1.08	1.05	160.

TABLE E.1 (PAGE 3)

NEW ESTABLISHMENT CRITERIA RESULTS
LOCATIONS WITH BENEFIT/COST RATIO > OR = 0.25

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
2V2	LONGMONT	CO	ANM	0	0.42	0.34	-2106.
MTJ	MONTROSE	CO	ANM	0	0.40	0.33	-2107.
SUN	HAILEY	ID	ANM	0	0.31	0.25	-2382.
BZN	BOZEMAN	MT	ANM	0	0.32	0.26	-2342.
BTM	BUTTE	MT	ANM	0	0.35	0.28	-2276.
S12	ALBANY	OR	ANM	0	0.46	0.33	-2115.
3S2	AURORA	OR	ANM	0	1.15	1.19	588.
4S5	MC MINNVILLE	OR	ANM	0	0.46	0.34	-2095.
OTH	NORTH BEND	OR	ANM	0	0.85	0.75	-801.
RDM	REDMOND	OR	ANM	0	0.39	0.33	-2135.
PVU	PROVO	UT	ANM	0	0.49	0.35	-2061.
U42	SALT LAKE CITY	UT	ANM	0	0.60	0.52	-1519.
SGU	ST. GEORGE	UT	ANM	0	0.46	0.44	-1784.
S88	ARLINGTON	WA	ANM	0	0.75	0.84	-516.
S50	AUBURN	WA	ANM	0	0.86	1.10	303.
BLI	BELLINGHAM	WA	ANM	0	0.40	0.30	-2206.
PWT	BREMERTON	WA	ANM	0	0.56	0.44	-1779.
EPH	EPHRATA	WA	ANM	0	0.44	0.33	-2134.
KLS	KELSO	WA	ANM	0	0.41	0.30	-2229.
CLM	PORT ANGELES	WA	ANM	0	0.44	0.38	-1952.
1S0	PUYALLUP	WA	ANM	0	0.65	0.71	-915.
RLD	RICHLAND	WA	ANM	0	0.56	0.48	-1648.
59S	VANCOUVER	WA	ANM	0	0.72	0.58	-1331.
60S	VANCOUVER	WA	ANM	0	0.50	0.31	-2198.
EAT	WENATCHEE	WA	ANM	0	0.38	0.31	-2172.
ANB	ANNISTON	AL	ASO	0	0.41	0.37	-1981.
12J	BREWTON	AL	ASO	0	0.45	0.40	-1906.
DCU	DECATUR	AL	ASO	0	0.42	0.28	-2279.
39J	EVERGREEN	AL	ASO	0	2.43	2.87	5930.
MSL	MUSCLE SHOALS	AL	ASO	0	0.39	0.32	-2148.
BCT	BOCA RATON	FL	ASO	0	0.40	0.28	-2289.
CLW	CLEARWATER	FL	ASO	0	0.38	0.26	-2336.
COI	COCOA	FL	ASO	0	0.45	0.31	-2172.
81J	DESTIN	FL	ASO	0	0.39	0.27	-2299.
FPR	FORT PIERCE	FL	ASO	7	0.77	0.69	-984.
X51	HOMESTEAD	FL	ASO	0	0.49	0.35	-2046.
MTH	MARATHON	FL	ASO	0	0.41	0.37	-2003.
APF	NAPLES	FL	ASO	0	0.59	0.54	-1467.
34J	NEW SMYRNA BEACH	FL	ASO	0	0.59	0.45	-1746.
X26	SEBASTIAN	FL	ASO	0	0.47	0.33	-2122.
VNC	VENICE	FL	ASO	0	0.48	0.35	-2049.
LNA	WEST PALM BEACH	FL	ASO	0	0.41	0.29	-2248.
8A4	MARIETTA	GA	ASO	0	0.49	0.35	-2075.
FFT	FRANKFORT	KY	ASO	0	1.36	1.44	1380.
LOZ	LONDON	KY	ASO	0	0.46	0.35	-2054.
HBG	HATTIESBURG	MS	ASO	0	0.37	0.26	-2356.
MBO	MADISON	MS	ASO	0	0.44	0.29	-2236.
TUP	TUPELO	MS	ASO	0	0.56	0.53	-1503.
OAJ	JACKSONVILLE	NC	ASO	0	0.30	0.26	-2346.
MEB	MAXTON	NC	ASO	0	0.34	0.28	-2296.

TABLE E.1 (PAGE 4)

NEW ESTABLISHMENT CRITERIA RESULTS
LOCATIONS WITH BENEFIT/COST RATIO > OR = 0.25

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
BQN	AGUADILLA	PR	ASO	0	0.48	0.38	-1953.
VQS	ISLA DE VIEQUES	PR	ASO	0	0.30	0.26	-2345.
CUB	COLUMBIA	SC	ASO	0	0.64	0.52	-1520.
49J	HILTON HEAD ISLAND	SC	ASO	0	0.38	0.31	-2202.
CSV	CROSSVILLE	TN	ASO	0	0.36	0.25	-2365.
MKL	JACKSON	TN	ASO	0	0.33	0.28	-2297.
JBR	JONESBORO	AR	ASW	0	0.71	0.69	-989.
H37	SPRINGDALE	AR	ASW	0	0.45	0.36	-2042.
LA96	FRANKLIN	LA	ASW	0	0.33	0.29	-2244.
HUM	HOUMA	LA	ASW	7	1.37	1.63	2005.
PTN	PATTERSON	LA	ASW	0	0.40	0.29	-2238.
Q64	ALBUQUERQUE	NM	ASW	0	0.50	0.32	-2143.
4AC	ALBUQUERQUE	NM	ASW	0	0.90	0.77	-714.
CKA	CHEROKEE	OK	ASW	0	0.96	0.94	-175.
FDR	FREDERICK	OK	ASW	0	1.71	1.87	2750.
PNC	PONCA CITY	OK	ASW	0	0.34	0.25	-2379.
SWO	STILLWATER	OK	ASW	0	0.41	0.28	-2284.
1H6	TULSA	OK	ASW	0	0.58	0.42	-1848.
TDW	AMARILLO	TX	ASW	0	0.62	0.47	-1684.
F54	ARLINGTON	TX	ASW	0	0.45	0.26	-2357.
3R3	AUSTIN	TX	ASW	0	0.68	0.53	-1496.
DTO	DENTON	TX	ASW	0	0.52	0.36	-2017.
F70	FORT WORTH	TX	ASW	0	0.62	0.46	-1713.
GLS	GALVESTON	TX	ASW	0	0.83	0.69	-988.
F67	GRAND PRAIRIE	TX	ASW	0	0.75	0.55	-1434.
HDO	HONDO	TX	ASW	0	1.77	1.94	2973.
AAP	HOUSTON	TX	ASW	0	0.43	0.29	-2243.
HPY	HOUSTON	TX	ASW	0	0.60	0.44	-1762.
SGR	HOUSTON	TX	ASW	0	0.98	0.93	-235.
T02	HOUSTON	TX	ASW	0	1.16	1.23	718.
T17	HOUSTON	TX	ASW	0	0.48	0.34	-2095.
ILE	KILLEEN	TX	ASW	0	1.29	1.52	1638.
T41	LA PORTE	TX	ASW	0	0.54	0.40	-1895.
F42	MESQUITE	TX	ASW	0	0.41	0.27	-2328.
MDD	MIDLAND	TX	ASW	0	0.77	0.63	-1168.
E02	ODESSA	TX	ASW	0	0.61	0.46	-1713.
T29	PEARLAND	TX	ASW	0	0.62	0.53	-1498.
F26	PLANO	TX	ASW	0	1.05	1.19	596.
TPL	TEMPLE	TX	ASW	0	0.42	0.30	-2206.
P10	CHANDLER	AZ	AWP	0	0.39	0.25	-2373.
P37	GLENDALE	AZ	AWP	0	0.64	0.52	-1533.
PGA	PAGE	AZ	AWP	0	0.41	0.36	-2031.
PRC	PRESCOTT	AZ	AWP	0	0.97	1.22	697.
ACV	ARCATA/EUREKA/	CA	AWP	0	0.52	0.34	-2094.
CMA	CAMARILLO	CA	AWP	0	0.93	0.77	-720.
O22	COLUMBIA	CA	AWP	0	0.56	0.38	-1958.
CPM	COMPTON	CA	AWP	0	0.72	0.61	-1229.
L66	CORONA	CA	AWP	0	1.27	1.28	898.
EKA	EUREKA	CA	AWP	0	0.58	0.41	-1860.
O11	FAIR OAKS	CA	AWP	0	0.43	0.27	-2322.

TABLE E.1 (PAGE 5)

NEW ESTABLISHMENT CRITERIA RESULTS
LOCATIONS WITH BENEFIT/COST RATIO > OR = 0.25

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
Q60	FRESNO	CA	AWP	0	0.48	0.32	-2166.
O17	GRASS VALLEY	CA	AWP	0	0.45	0.28	-2271.
L16	HUNTINGTON BEACH	CA	AWP	0	0.42	0.27	-2304.
LPC	LOMPOC	CA	AWP	0	0.51	0.31	-2171.
WHP	LOS ANGELES	CA	AWP	0	0.60	0.49	-1613.
O56	NOVATO	CA	AWP	0	0.93	0.69	-970.
OVE	OROVILLE	CA	AWP	0	0.48	0.31	-2179.
PRB	PASO ROBLES	CA	AWP	0	0.61	0.45	-1751.
PTV	PORTERVILLE	CA	AWP	0	0.46	0.29	-2236.
O85	REDDING	CA	AWP	0	0.40	0.25	-2383.
L67	RIALTO	CA	AWP	0	0.58	0.41	-1860.
SBP	SAN LUIS OBISPO	CA	AWP	0	0.81	0.69	-974.
Q99	SAN MARTIN	CA	AWP	0	0.47	0.28	-2270.
TRK	TRUCKEE	CA	AWP	0	0.42	0.27	-2323.
CCB	UPLAND	CA	AWP	0	0.51	0.36	-2014.
O45	VACAVILLE	CA	AWP	0	0.61	0.42	-1828.
VIS	VISALIA	CA	AWP	0	0.68	0.55	-1420.
NPS	HONOLULU	HI	AWP	0	0.66	0.50	-1575.
HDH	MOKULEIA	HI	AWP	0	0.92	0.83	-530.
L15	LAS VEGAS	NV	AWP	0	0.44	0.29	-2236.

TABLE E.2 (PAGE 1)

NEW DISCONTINUANCE CRITERIA RESULTS
ALL LOCATIONS WITH TOWERS

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
ANC	ANCHORAGE	AK	AAL	1	5.85	17.26	29076.
LHD	ANCHORAGE	AK	AAL	1	1.19	1.24	434.
MRI	ANCHORAGE	AK	AAL	1	2.79	6.04	9008.
FAI	FAIRBANKS	AK	AAL	1	3.28	8.88	14093.
JNU	JUNEAU	AK	AAL	1	1.86	2.98	3539.
ENA	KENAI	AK	AAL	1	1.41	1.98	1747.
AKN	KING SALMON	AK	AAL	1	1.19	1.46	826.
ADQ	KODIAK	AK	AAL	1	1.33	1.60	1073.
VDZ	VALDEZ	AK	AAL	1	0.25	0.22	-1387.
CID	CEDAR RAPIDS	IA	ACE	1	2.03	4.13	5607.
DSM	DES MOINES	IA	ACE	1	4.13	12.03	19722.
DBQ	DUBUQUE	IA	ACE	1	1.04	0.94	-100.
SUX	SIOUX CITY	IA	ACE	1	1.80	2.93	3444.
ALO	WATERLOO	IA	ACE	1	1.63	2.75	3135.
HUT	HUTCHINSON	KS	ACE	1	1.26	1.39	690.
KCK	KANSAS CITY	KS	ACE	1	1.25	1.73	1303.
OJC	OLATHE	KS	ACE	1	1.29	1.26	466.
SLN	SALINA	KS	ACE	1	1.00	1.22	392.
FOE	TOPEKA	KS	ACE	1	1.78	2.22	2185.
TOP	TOPEKA	KS	ACE	1	1.04	0.95	-87.
ICT	WICHITA	KS	ACE	1	4.98	15.24	25477.
CGI	CAPE GIRARDEAU	MO	ACE	1	0.74	0.69	-563.
COU	COLUMBIA	MO	ACE	1	0.81	1.27	480.
JLN	JOPLIN	MO	ACE	1	0.76	1.02	35.
MCI	KANSAS CITY	MO	ACE	1	9.27	27.23	46908.
MKC	KANSAS CITY	MO	ACE	1	2.40	3.11	3781.
SGF	SPRINGFIELD	MO	ACE	1	1.96	3.99	5345.
STJ	ST JOSEPH	MO	ACE	1	0.84	0.82	-325.
STL	ST LOUIS	MO	ACE	1	15.96	64.74	114004.
SUS	ST LOUIS	MO	ACE	1	1.90	3.53	4524.
GRI	GRAND ISLAND	NE	ACE	1	1.06	1.17	304.
LNK	LINCOLN	NE	ACE	1	3.43	7.96	12448.
OMA	OMAHA	NE	ACE	1	4.22	12.73	20972.
DCA	WASHINGTON	DC	AEA	1	16.25	63.73	112198.
IAD	WASHINGTON	DC	AEA	1	4.46	13.84	22965.
ILG	WILMINGTON	DE	AEA	1	2.33	3.50	4479.
BWI	BALTIMORE	MD	AEA	1	7.15	25.92	44573.
ADW	CAMP SPRINGS	MD	AEA	1	5.31	7.33	11321.
HGR	HAGERSTOWN	MD	AEA	1	1.12	1.14	244.
ACY	ATLANTIC CITY	NJ	AEA	1	2.61	3.98	5332.
CDW	CALDWELL	NJ	AEA	1	1.91	2.64	2926.
MMU	MORRISTOWN	NJ	AEA	1	3.10	4.11	5564.
EWR	NEWARK	NJ	AEA	1	9.44	30.59	52932.
TEB	TETERBORO	NJ	AEA	1	4.33	7.44	11520.
TTN	TRENTON	NJ	AEA	1	2.20	2.81	3238.
ALB	ALBANY	NY	AEA	1	3.81	7.68	11940.
BGM	BINGHAMTON	NY	AEA	1	1.34	1.44	782.
BUF	BUFFALO	NY	AEA	1	5.89	16.02	26860.
ELM	ELMIRA	NY	AEA	1	1.23	1.38	685.
FRG	FARMINGDALE	NY	AEA	1	3.09	3.60	4650.

TABLE E.2 (PAGE 2)

NEW DISCONTINUANCE CRITERIA RESULTS
ALL LOCATIONS WITH TOWERS

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
ISP	ISLIP	NY	AEA	1	3.58	6.92	10591.
ITH	ITHACA	NY	AEA	1	1.16	1.28	499.
JFK	NEW YORK	NY	AEA	1	17.33	63.34	111501.
LGA	NEW YORK	NY	AEA	1	16.64	62.85	110621.
IAG	NIAGARA FALLS	NY	AEA	1	2.43	3.06	3676.
POU	POUGHKEEPSIE	NY	AEA	1	1.97	2.57	2815.
ROC	ROCHESTER	NY	AEA	1	4.84	14.98	25003.
SYR	SYRACUSE	NY	AEA	1	4.46	10.06	16201.
UCA	UTICA	NY	AEA	1	1.24	2.55	2769.
HPN	WHITE PLAINS	NY	AEA	1	2.80	4.71	6641.
ABE	ALLENTOWN	PA	AEA	1	1.95	3.08	3723.
ERI	ERIE	PA	AEA	1	1.24	1.53	951.
CXY	HARRISBURG	PA	AEA	1	1.23	1.22	385.
LNS	LANCASTER	PA	AEA	1	2.09	2.74	3118.
MDT	MIDDLETOWN	PA	AEA	1	2.48	3.92	5230.
PHL	PHILADELPHIA	PA	AEA	1	12.73	56.41	99114.
PNE	PHILADELPHIA	PA	AEA	1	2.75	3.73	4876.
AGC	PITTSBURGH	PA	AEA	1	1.87	2.01	1800.
PIT	PITTSBURGH	PA	AEA	1	16.60	79.52	140442.
RDG	READING	PA	AEA	1	1.86	2.29	2301.
AVP	WILKES-BARRE/SCRANTON	PA	AEA	1	1.71	2.32	2362.
IPT	WILLIAMSPORT	PA	AEA	1	1.16	1.19	342.
CHO	CHARLOTTESVILLE	VA	AEA	1	1.31	1.74	1327.
LYH	LYNCHBURG	VA	AEA	1	1.41	1.99	1780.
PHF	NEWPORT NEWS	VA	AEA	1	3.18	5.31	7704.
ORF	NORFOLK	VA	AEA	1	4.60	13.73	22768.
RIC	RICHMOND	VA	AEA	1	4.68	11.12	18105.
ROA	ROANOKE	VA	AEA	1	3.31	7.41	11466.
CRW	CHARLESTON	WV	AEA	1	2.52	4.37	6034.
CKB	CLARKSBURG	WV	AEA	1	0.98	1.08	135.
HTS	HUNTINGTON	WV	AEA	1	1.38	1.85	1520.
LWB	LEWISBURG	WV	AEA	1	0.42	0.37	-1130.
MGW	MORGANTOWN	WV	AEA	1	0.94	0.95	-89.
PKB	PARKERSBURG	WV	AEA	1	1.47	1.55	992.
HLG	WHEELING	WV	AEA	1	0.88	0.79	-376.
ALN	ALTON	IL	AGL	1	1.47	1.46	827.
ARR	AURORA	IL	AGL	1	1.57	1.79	1419.
BMI	BLOOMINGTON-NORMAL	IL	AGL	1	1.02	1.85	1517.
MDH	CARBONDALE/MURPHYSBORO	IL	AGL	1	1.80	2.11	1978.
CMI	CHAMPAIGN/URBANA/	IL	AGL	1	2.64	4.77	6744.
CGX	CHICAGO	IL	AGL	1	1.23	0.97	-54.
MDW	CHICAGO	IL	AGL	1	3.82	12.40	20397.
ORD	CHICAGO	IL	AGL	1	41.84	336.11	599367.
DPA	CHICAGO/WEST CHICAGO/	IL	AGL	1	2.69	3.84	5082.
PWK	CHICAGO/WHEELING/	IL	AGL	1	2.96	4.87	6921.
DNV	DANVILLE	IL	AGL	1	0.46	0.62	-672.
DEC	DECATUR	IL	AGL	1	1.55	2.00	1794.
CPS	EAST ST LOUIS	IL	AGL	1	1.89	1.83	1479.
GBG	GALESBURG	IL	AGL	1	0.63	0.57	-769.
MWA	MARION	IL	AGL	1	0.91	0.83	-300.

TABLE E.2 (PAGE 3)

NEW DISCONTINUANCE CRITERIA RESULTS
ALL LOCATIONS WITH TOWERS

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
MLI	MOLINE	IL	AGL	1	2.37	4.45	6175.
PIA	PEORIA	IL	AGL	1	2.67	4.74	6694.
RFD	ROCKFORD	IL	AGL	1	2.33	3.22	3968.
SPI	SPRINGFIELD	IL	AGL	1	2.25	3.39	4283.
BMG	BLOOMINGTON	IN	AGL	1	0.83	0.97	-53.
EVV	EVANSVILLE	IN	AGL	1	1.68	2.33	2388.
FWA	FORT WAYNE	IN	AGL	1	3.00	5.70	8398.
IND	INDIANAPOLIS	IN	AGL	1	6.49	18.76	31757.
LAF	LAFAYETTE	IN	AGL	1	1.67	2.72	3081.
MIE	MUNCIE	IN	AGL	1	1.03	1.41	739.
SBN	SOUTH BEND	IN	AGL	1	1.99	3.91	5204.
HUF	TERRE HAUTE	IN	AGL	1	1.64	2.81	3243.
ARB	ANN ARBOR	MI	AGL	1	1.18	1.21	372.
BTL	BATTLE CREEK	MI	AGL	1	1.25	1.49	884.
BEH	BENTON HARBOR	MI	AGL	1	0.57	0.47	-943.
DET	DETROIT	MI	AGL	1	2.22	2.91	3408.
DTW	DETROIT	MI	AGL	1	13.66	49.23	86271.
YIP	DETROIT	MI	AGL	1	2.54	5.20	7521.
FNT	FLINT	MI	AGL	1	2.13	3.63	4698.
GRR	GRAND RAPIDS	MI	AGL	1	3.42	6.85	10461.
JXN	JACKSON	MI	AGL	1	1.10	0.87	-239.
AZO	KALAMAZOO	MI	AGL	1	1.67	2.22	2184.
LAN	LANSING	MI	AGL	1	2.59	4.78	6757.
MKG	MUSKEGON	MI	AGL	1	1.19	1.43	766.
PTK	PONTIAC	MI	AGL	1	3.11	5.25	7599.
MBS	SAGINAW	MI	AGL	1	1.63	1.84	1500.
TVC	TRAVERSE CITY	MI	AGL	1	1.79	2.33	2372.
DLH	DULUTH	MN	AGL	1	2.17	2.31	2338.
FCM	MINNEAPOLIS	MN	AGL	1	2.31	3.50	4470.
MIC	MINNEAPOLIS	MN	AGL	1	1.91	2.62	2896.
MSP	MINNEAPOLIS	MN	AGL	1	12.81	51.93	91088.
RST	ROCHESTER	MN	AGL	1	1.85	2.79	3193.
STP	ST PAUL	MN	AGL	1	1.97	2.45	2600.
BIS	BISMARCK	ND	AGL	1	2.20	3.13	3806.
FAR	FARGO	ND	AGL	1	2.15	3.67	4773.
GFK	GRAND FORKS	ND	AGL	1	2.73	6.05	9038.
MOT	MINOT	ND	AGL	1	0.74	0.72	-509.
AKR	AKRON	OH	AGL	1	0.85	0.62	-678.
CAK	AKRON	OH	AGL	1	2.84	4.15	5629.
LUK	CINCINNATI	OH	AGL	1	1.95	2.59	2841.
BKL	CLEVELAND	OH	AGL	1	1.30	2.22	2178.
CGF	CLEVELAND	OH	AGL	1	1.19	1.08	145.
CLE	CLEVELAND	OH	AGL	1	10.66	36.69	63835.
CMH	COLUMBUS	OH	AGL	1	6.07	18.91	32038.
OSU	COLUMBUS	OH	AGL	1	2.25	3.16	3858.
DAY	DAYTON	OH	AGL	1	4.30	9.90	15920.
MFD	MANSFIELD	OH	AGL	1	1.21	1.23	415.
TOL	TOLEDO	OH	AGL	1	2.27	3.01	3599.
YNG	YOUNGSTOWN	OH	AGL	1	1.88	2.42	2548.
RAP	RAPID CITY	SD	AGL	1	1.67	2.39	2481.

TABLE E.2 (PAGE 4)

NEW DISCONTINUANCE CRITERIA RESULTS
ALL LOCATIONS WITH TOWERS

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
FSD	SIOUX FALLS	SD	AGL	1	2.52	3.91	5196.
ATW	APPLETON	WI	AGL	1	1.39	2.12	2011.
GRB	GREEN BAY	WI	AGL	1	2.57	4.50	6258.
JVL	JANESVILLE	WI	AGL	1	1.80	1.92	1649.
LSE	LA CROSSE	WI	AGL	1	1.35	1.56	999.
MSN	MADISON	WI	AGL	1	4.00	8.68	13743.
MKE	MILWAUKEE	WI	AGL	1	8.07	27.91	48126.
MWC	MILWAUKEE	WI	AGL	1	1.40	1.51	919.
OSH	OSHKOSH	WI	AGL	1	1.73	2.27	2272.
BDR	BRIDGEPORT	CT	ANE	1	2.20	2.97	3527.
DXR	DANBURY	CT	ANE	1	1.68	1.87	1552.
GON	GROTON/NEW LONDON/	CT	ANE	1	2.00	2.67	2985.
HFD	HARTFORD	CT	ANE	1	2.08	2.43	2554.
HVN	NEW HAVEN	CT	ANE	1	2.32	2.63	2921.
BDL	WINDSOR LOCKS	CT	ANE	1	5.61	13.76	22820.
BED	BEDFORD	MA	ANE	1	2.83	4.12	5579.
BVY	BEVERLY	MA	ANE	1	1.61	1.77	1382.
BOS	BOSTON	MA	ANE	1	16.48	76.01	134169.
FMH	FALMOUTH	MA	ANE	1	1.64	1.70	1252.
HYA	HYANNIS	MA	ANE	1	2.73	3.18	3899.
LWM	LAWRENCE	MA	ANE	1	1.92	1.26	465.
MVY	MARTHAS VINEYARD	MA	ANE	1	0.61	0.54	-831.
ACK	NANTUCKET	MA	ANE	1	1.99	1.93	1671.
EWB	NEW BEDFORD	MA	ANE	1	1.22	1.09	164.
OWD	NORWOOD	MA	ANE	1	2.20	2.61	2886.
BAF	WESTFIELD	MA	ANE	1	2.55	3.38	4264.
ORH	WORCESTER	MA	ANE	1	1.28	1.17	298.
BGR	BANGOR	ME	ANE	1	2.10	2.98	3546.
PWM	PORTLAND	ME	ANE	1	1.84	2.99	3563.
LEB	LEBANON	NH	ANE	1	0.94	0.56	-789.
MHT	MANCHESTER	NH	ANE	1	2.01	2.57	2811.
PVD	PROVIDENCE	RI	ANE	1	4.66	11.41	18622.
BTV	BURLINGTON	VT	ANE	1	2.56	3.62	4680.
ASE	ASPEN	CO	ANM	1	1.00	1.19	334.
COS	COLORADO SPRINGS	CO	ANM	1	3.64	7.21	11099.
APA	DENVER	CO	ANM	1	4.07	8.47	13360.
BJC	DENVER	CO	ANM	1	1.87	2.52	2714.
DEN	DENVER	CO	ANM	1	24.10	152.73	271374.
GJT	GRAND JUNCTION	CO	ANM	1	1.56	2.25	2239.
PUB	PUEBLO	CO	ANM	1	1.95	2.55	2776.
BOI	BOISE	ID	ANM	1	4.60	11.56	18880.
IDA	IDAHO FALLS	ID	ANM	1	0.70	1.06	105.
LWS	LEWISTON	ID	ANM	1	1.08	1.63	1121.
PIH	POCATELLO	ID	ANM	1	1.00	1.16	290.
TWF	TWIN FALLS	ID	ANM	1	0.90	1.14	252.
BIL	BILLINGS	MT	ANM	1	2.81	5.60	8229.
GTF	GREAT FALLS	MT	ANM	1	1.78	2.50	2684.
HLN	HELENA	MT	ANM	1	1.54	1.76	1351.
MSO	MISSOULA	MT	ANM	1	1.08	1.21	372.
EUG	EUGENE	OR	ANM	1	2.66	5.97	8881.

TABLE E.2 (PAGE 5)

NEW DISCONTINUANCE CRITERIA RESULTS
ALL LOCATIONS WITH TOWERS

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
HIO	HILLSBORO	OR	ANM	1	1.99	2.68	2997.
LMT	KLAMATH FALLS	OR	ANM	1	1.14	1.40	716.
MFR	MEDFORD	OR	ANM	1	1.85	2.85	3310.
PDT	PENDLETON	OR	ANM	1	0.74	0.63	-657.
PDX	PORTLAND	OR	ANM	1	7.87	23.96	41069.
SLE	SALEM	OR	ANM	1	1.71	2.40	2507.
TTD	TROUTDALE	OR	ANM	1	1.28	1.13	231.
OGD	OGDEN	UT	ANM	1	1.17	1.24	437.
SLC	SALT LAKE CITY	UT	ANM	1	8.74	34.59	60080.
PAE	EVERETT	WA	ANM	1	2.58	6.65	10098.
MWH	MOSES LAKE	WA	ANM	1	1.79	2.07	1912.
OLM	OLYMPIA	WA	ANM	1	0.98	1.38	686.
PSC	PASCO	WA	ANM	1	1.77	5.05	7246.
RNT	RENTON	WA	ANM	1	1.45	2.26	2245.
BFI	SEATTLE	WA	ANM	1	4.86	9.21	14680.
SEA	SEATTLE	WA	ANM	1	10.97	30.96	53584.
GEG	SPOKANE	WA	ANM	1	3.67	10.83	17584.
SFF	SPOKANE	WA	ANM	1	1.31	1.47	839.
TIW	TACOMA	WA	ANM	1	1.22	1.50	891.
ALW	WALLA WALLA	WA	ANM	1	0.82	0.94	-115.
YKM	YAKIMA	WA	ANM	1	1.76	2.96	3513.
CPR	CASPER	WY	ANM	1	1.70	2.35	2414.
CYS	CHEYENNE	WY	ANM	1	1.70	2.14	2044.
BHM	BIRMINGHAM	AL	ASO	1	5.18	14.13	23491.
DHN	DOTHAN	AL	ASO	1	3.14	4.40	6089.
HSV	HUNTSVILLE	AL	ASO	1	1.92	3.15	3853.
MOB	MOBILE	AL	ASO	1	3.17	5.81	8598.
MGM	MONTGOMERY	AL	ASO	1	2.38	3.71	4844.
TCL	TUSCALOOSA	AL	ASO	1	1.11	1.25	440.
DAB	DAYTONA BEACH	FL	ASO	1	4.22	12.35	20301.
FLL	FT LAUDERDALE	FL	ASO	1	8.80	32.95	57153.
FXE	FT LAUDERDALE	FL	ASO	1	2.34	3.37	4237.
FMY	FT MYERS	FL	ASO	1	2.75	5.83	8635.
GNV	GAINESVILLE	FL	ASO	1	1.58	2.42	2532.
HWO	HOLLYWOOD	FL	ASO	1	2.52	5.04	7221.
CRG	JACKSONVILLE	FL	ASO	1	1.66	2.11	1978.
JAX	JACKSONVILLE	FL	ASO	1	4.35	9.30	14848.
EYW	KEY WEST	FL	ASO	1	0.92	1.08	148.
MLB	MELBOURNE	FL	ASO	1	3.22	8.21	12899.
MIA	MIAMI	FL	ASO	1	20.38	100.63	178202.
OPF	MIAMI	FL	ASO	1	5.08	11.68	19110.
TMB	MIAMI	FL	ASO	1	4.19	9.01	14332.
TNT	MIAMI	FL	ASO	1	0.33	0.16	-1508.
MCO	ORLANDO	FL	ASO	1	8.55	26.35	45344.
ORL	ORLANDO	FL	ASO	1	2.22	3.56	4586.
PFN	PANAMA CITY	FL	ASO	1	1.76	2.80	3225.
PNS	PENSACOLA	FL	ASO	1	2.00	3.17	3885.
PMP	POMPANO BEACH	FL	ASO	1	1.69	2.32	2365.
SRQ	SARASOTA/BRADENTON/	FL	ASO	1	3.08	7.02	10770.
SPG	ST PETERSBURG	FL	ASO	1	1.20	1.02	31.

TABLE E.2 (PAGE 6)

NEW DISCONTINUANCE CRITERIA RESULTS
ALL LOCATIONS WITH TOWERS

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
PIE	ST PETERSBURG/CLEARWAT	FL	ASO	1	2.94	5.28	7664.
TLH	TALLAHASSEE	FL	ASO	1	2.23	4.00	5360.
TPA	TAMPA	FL	ASO	1	10.84	38.72	67469.
VRB	VERO BEACH	FL	ASO	1	2.43	4.05	5462.
PBI	WEST PALM BEACH	FL	ASO	1	6.10	19.84	33706.
ABY	ALBANY	GA	ASO	1	1.68	2.40	2506.
AHN	ATHENS	GA	ASO	1	0.72	0.59	-733.
ATL	ATLANTA	GA	ASO	1	37.40	332.19	592356.
FTY	ATLANTA	GA	ASO	1	2.68	4.02	5401.
PDK	ATLANTA	GA	ASO	1	2.77	4.16	5657.
AGS	AUGUSTA	GA	ASO	1	1.48	2.05	1885.
SSI	BRUNSWICK	GA	ASO	1	0.37	0.22	-1390.
CSG	COLUMBUS	GA	ASO	1	1.33	1.70	1246.
MCN	MACON	GA	ASO	1	0.85	0.94	-116.
SAV	SAVANNAH	GA	ASO	1	2.48	4.48	6222.
VLD	VALDOSTA	GA	ASO	1	0.67	0.66	-608.
CVG	COVINGTON/CINCINNATI,	KY	ASO	1	4.85	11.57	18910.
LEX	LEXINGTON	KY	ASO	1	2.51	4.76	6732.
LOU	LOUISVILLE	KY	ASO	1	2.08	3.29	4096.
SDF	LOUISVILLE	KY	ASO	1	4.86	11.26	18351.
OWB	OWENSBORO	KY	ASO	1	0.68	0.63	-662.
PAH	PADUCAH	KY	ASO	1	0.65	0.66	-615.
GLH	GREENVILLE	MS	ASO	1	0.90	0.98	-35.
GPT	GULFPORT	MS	ASO	1	1.70	2.17	2091.
HKS	JACKSON	MS	ASO	1	1.25	1.40	711.
JAN	JACKSON	MS	ASO	1	3.17	5.13	7384.
MEI	MERIDIAN	MS	ASO	1	1.47	1.68	1208.
AVL	ASHEVILLE	NC	ASO	1	1.46	2.11	1985.
CLT	CHARLOTTE	NC	ASO	1	7.62	27.30	47036.
FAY	FAYETTEVILLE	NC	ASO	1	1.61	2.33	2385.
GSO	GREENSBORO	NC	ASO	1	4.06	10.63	17229.
HKY	HICKORY	NC	ASO	1	0.76	0.62	-684.
ISO	KINSTON	NC	ASO	1	0.93	0.94	-101.
EWN	NEW BERN	NC	ASO	1	0.72	0.69	-552.
RDU	RALEIGH-DURHAM	NC	ASO	1	5.19	15.53	25988.
ILM	WILMINGTON	NC	ASO	1	1.91	2.83	3281.
INT	WINSTON SALEM	NC	ASO	1	1.36	1.85	1525.
MAZ	MAYAGUEZ	PR	ASO	1	0.36	0.30	-1255.
PSE	PONCE	PR	ASO	1	0.38	0.30	-1250.
SIG	SAN JUAN	PR	ASO	1	1.48	1.73	1309.
SJU	SAN JUAN	PR	ASO	1	6.36	17.83	30107.
CHS	CHARLESTON	SC	ASO	1	5.05	9.54	15271.
CAE	COLUMBIA	SC	ASO	1	2.99	6.33	9531.
FLO	FLORENCE	SC	ASO	1	1.05	0.95	-84.
GMU	GREENVILLE	SC	ASO	1	1.16	1.37	663.
GSP	GREER	SC	ASO	1	1.45	2.03	1843.
CRE	NORTH MYRTLE BEACH	SC	ASO	1	0.91	0.93	-126.
SPA	SPARTANBURG	SC	ASO	1	0.71	0.66	-609.
TRI	BRISTOL/JOHNSON/KINGSP	TN	ASO	1	2.16	3.77	4952.
CHA	CHATTANOOGA	TN	ASO	1	2.09	3.63	4701.

TABLE E.2 (PAGE 7)

NEW DISCONTINUANCE CRITERIA RESULTS
ALL LOCATIONS WITH TOWERS

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
DKX	KNOXVILLE	TN	ASO	1	0.72	0.64	-642.
TYS	KNOXVILLE	TN	ASO	1	3.13	6.54	9903.
MEM	MEMPHIS	TN	ASO	1	12.61	62.58	110143.
BNA	NASHVILLE	TN	ASO	1	6.42	20.71	35253.
STT	CHARLOTTE AMALIE	VI	ASO	1	2.67	4.23	5781.
STX	CHRISTIANSTED	VI	ASO	1	2.02	2.90	3401.
FYV	FAYETTEVILLE	AR	ASW	1	1.17	1.30	541.
FSM	FORT SMITH	AR	ASW	1	1.78	2.59	2846.
HOT	HOT SPRINGS	AR	ASW	1	0.74	0.70	-539.
LIT	LITTLE ROCK	AR	ASW	1	3.56	7.38	11409.
PBF	PINE BLUFF	AR	ASW	1	0.51	0.44	-1001.
TXK	TEXARKANA	AR	ASW	1	0.91	0.74	-462.
AWM	WEST MEMPHIS	AR	ASW	1	0.68	0.63	-665.
ESF	ALEXANDRIA	LA	ASW	1	0.76	0.77	-415.
BTR	BATON ROUGE	LA	ASW	1	2.51	4.92	7007.
LFT	LAFAYETTE	LA	ASW	1	3.06	7.73	12037.
LCH	LAKE CHARLES	LA	ASW	1	1.17	1.19	331.
MLU	MONROE	LA	ASW	1	1.63	2.33	2371.
MSY	NEW ORLEANS	LA	ASW	1	8.73	26.36	45351.
NEW	NEW ORLEANS	LA	ASW	1	2.73	5.30	7689.
DTN	SHREVEPORT	LA	ASW	1	1.13	1.15	265.
SHV	SHREVEPORT	LA	ASW	1	2.38	3.85	5105.
ABQ	ALBUQUERQUE	NM	ASW	1	7.27	18.16	30685.
FMN	FARMINGTON	NM	ASW	1	1.36	1.65	1164.
HOB	HOBBS	NM	ASW	1	0.59	0.56	-791.
ROW	ROSWELL	NM	ASW	1	1.81	2.13	2022.
SAF	SANTA FE	NM	ASW	1	1.01	0.96	-69.
ADM	ARDMORE	OK	ASW	1	0.69	0.56	-793.
CSM	CLINTON	OK	ASW	1	0.84	0.85	-275.
WDG	ENID	OK	ASW	1	0.82	1.03	62.
LAW	LAWTON	OK	ASW	1	1.32	1.65	1157.
OKC	OKLAHOMA CITY	OK	ASW	1	4.73	12.47	20517.
PWA	OKLAHOMA CITY	OK	ASW	1	2.12	3.07	3704.
RVS	TULSA	OK	ASW	1	2.95	4.56	6374.
TUL	TULSA	OK	ASW	1	5.47	14.36	23894.
ABI	ABILENE	TX	ASW	1	1.68	1.63	1131.
AMA	AMARILLO	TX	ASW	1	2.51	4.39	6070.
AUS	AUSTIN	TX	ASW	1	4.80	12.12	19896.
BPT	BEAUMONT/PORT ARTHUR	TX	ASW	1	1.84	1.01	12.
BRO	BROWNSVILLE	TX	ASW	1	1.37	1.71	1269.
CLL	COLLEGE STATION	TX	ASW	1	1.39	1.24	432.
CRP	CORPUS CHRISTI	TX	ASW	1	3.40	5.24	7578.
ADS	DALLAS	TX	ASW	1	2.09	2.12	2006.
DAL	DALLAS	TX	ASW	1	7.72	29.07	50197.
RBD	DALLAS	TX	ASW	1	1.93	2.29	2308.
DFW	DALLAS-FORT WORTH	TX	ASW	1	26.01	176.61	314086.
ELP	EL PASO	TX	ASW	1	5.30	13.65	22634.
FTW	FORT WORTH	TX	ASW	1	4.27	7.83	12223.
HRL	HARLINGEN	TX	ASW	1	1.24	1.13	235.
DWH	HOUSTON	TX	ASW	1	1.67	2.37	2451.

TABLE E.2 (PAGE 8)

NEW DISCONTINUANCE CRITERIA RESULTS
ALL LOCATIONS WITH TOWERS

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
HOU	HOUSTON	TX	ASW	1	7.40	35.96	62526.
IAH	HOUSTON	TX	ASW	1	13.66	76.95	135842.
LRD	LAREDO	TX	ASW	1	0.76	0.72	-492.
GGG	LONGVIEW	TX	ASW	1	1.36	1.31	555.
LBB	LUBBOCK	TX	ASW	1	2.88	5.69	8387.
MFE	MC ALLEN	TX	ASW	1	1.42	1.81	1455.
MAF	MIDLAND	TX	ASW	1	2.65	5.97	8895.
PVW	PLAINVIEW	TX	ASW	1	0.60	0.49	-909.
SJT	SAN ANGELO	TX	ASW	1	1.79	2.11	1992.
SAT	SAN ANTONIO	TX	ASW	1	6.58	18.45	31215.
SSF	SAN ANTONIO	TX	ASW	1	1.14	1.20	355.
TYR	TYLER	TX	ASW	1	1.21	1.11	202.
ACT	WACO	TX	ASW	1	1.14	0.90	-180.
FLG	FLAGSTAFF	AZ	AWP	1	1.01	1.24	434.
GYR	GOODYEAR	AZ	AWP	1	1.92	3.73	4880.
GCN	GRAND CANYON	AZ	AWP	1	2.24	2.98	3534.
DVT	PHOENIX	AZ	AWP	1	2.95	6.90	10548.
PHX	PHOENIX	AZ	AWP	1	12.48	57.07	100278.
SDL	SCOTTSDALE	AZ	AWP	1	2.64	4.16	5647.
TUS	TUCSON	AZ	AWP	1	6.37	22.91	39182.
BFL	BAKERSFIELD	CA	AWP	1	2.84	4.19	5707.
BUR	BURBANK	CA	AWP	1	4.75	10.04	16174.
CRQ	CARLSBAD	CA	AWP	1	2.78	4.50	6255.
CIC	CHICO	CA	AWP	1	0.98	0.96	-74.
CNO	CHINO	CA	AWP	1	2.08	2.79	3208.
CCR	CONCORD	CA	AWP	1	3.57	5.97	8883.
EMT	EL MONTE	CA	AWP	1	2.35	3.61	4673.
FAT	FRESNO	CA	AWP	1	4.82	11.59	18934.
FCH	FRESNO	CA	AWP	1	0.82	0.75	-444.
FUL	FULLERTON	CA	AWP	1	2.45	3.00	3574.
HHR	HAWTHORNE	CA	AWP	1	2.02	2.15	2055.
HWD	HAYWARD	CA	AWP	1	3.21	4.91	6987.
IPL	IMPERIAL	CA	AWP	1	1.31	1.50	898.
POC	LA VERNE	CA	AWP	1	2.26	3.15	3847.
WJF	LANCASTER	CA	AWP	1	1.56	1.88	1570.
LVK	LIVERMORE	CA	AWP	1	2.18	3.04	3653.
LGB	LONG BEACH	CA	AWP	1	7.20	20.95	35687.
LAX	LOS ANGELES	CA	AWP	1	30.00	180.49	321032.
MYV	MARYSVILLE	CA	AWP	1	0.79	0.80	-361.
MCE	MERCED	CA	AWP	1	1.01	1.10	181.
MOD	MODESTO	CA	AWP	1	1.94	2.70	3037.
MRY	MONTEREY	CA	AWP	1	2.63	3.98	5329.
APC	NAPA	CA	AWP	1	2.33	3.36	4216.
OAK	OAKLAND	CA	AWP	1	7.31	44.97	78641.
ONT	ONTARIO	CA	AWP	1	4.39	14.77	24622.
OXR	OXNARD	CA	AWP	1	2.66	4.87	6930.
PSP	PALM SPRINGS	CA	AWP	1	1.79	2.47	2620.
PMD	PALMDALE	CA	AWP	1	2.10	5.65	8313.
PAO	PALO ALTO	CA	AWP	1	2.53	4.42	6118.
RDD	REDDING	CA	AWP	1	1.32	1.58	1035.

TABLE E.2 (PAGE 9)

NEW DISCONTINUANCE CRITERIA RESULTS
ALL LOCATIONS WITH TOWERS

LOC ID	CITY	ST	REG	TCODE	PHASE I	B/C	B-C ($K)
RAL	RIVERSIDE	CA	AWP	1	1.90	3.61	4671.
SAC	SACRAMENTO	CA	AWP	1	2.46	3.42	4337.
SMF	SACRAMENTO	CA	AWP	1	4.41	10.04	16170.
SNS	SALINAS	CA	AWP	1	1.46	1.72	1282.
SQL	SAN CARLOS	CA	AWP	1	2.64	4.60	6443.
MYF	SAN DIEGO	CA	AWP	1	2.83	4.91	6999.
SAN	SAN DIEGO	CA	AWP	1	6.27	15.86	26579.
SDM	SAN DIEGO	CA	AWP	1	2.06	3.39	4282.
SEE	SAN DIEGO/EL CAJON/	CA	AWP	1	2.87	4.87	6921.
SFO	SAN FRANCISCO	CA	AWP	1	19.16	80.56	142294.
RHV	SAN JOSE	CA	AWP	1	3.38	6.32	9517.
SJC	SAN JOSE	CA	AWP	1	7.33	37.65	65553.
SNA	SANTA ANA	CA	AWP	1	7.93	27.21	46883.
SBA	SANTA BARBARA	CA	AWP	1	3.04	5.33	7749.
SMX	SANTA MARIA	CA	AWP	1	1.22	1.38	676.
SMO	SANTA MONICA	CA	AWP	1	2.53	2.90	3396.
STS	SANTA ROSA	CA	AWP	1	2.18	2.74	3110.
TVL	SOUTH LAKE TAHOE	CA	AWP	1	1.00	1.09	154.
SCK	STOCKTON	CA	AWP	1	2.18	3.29	4092.
TOA	TORRANCE	CA	AWP	1	3.93	7.42	11482.
VNY	VAN NUYS	CA	AWP	1	6.39	14.20	23615.
ITO	HILO	HI	AWP	1	1.80	2.15	2062.
HNL	HONOLULU	HI	AWP	1	13.55	62.30	109646.
OGG	KAHULUI	HI	AWP	1	4.14	8.43	13296.
KOA	KAILUA-KONA	HI	AWP	1	1.99	2.83	3265.
MKK	KAUNAKAKAI	HI	AWP	1	1.76	1.33	586.
LIH	LIHUE	HI	AWP	1	2.48	3.84	5072.
LAS	LAS VEGAS	NV	AWP	1	12.80	65.98	116229.
VGT	LAS VEGAS	NV	AWP	1	1.96	3.66	4749.
RNO	RENO	NV	AWP	1	5.82	13.07	21596.
KWA	KWAJALEIN/MARSHALL IS	SP	AWP	1	1.04	0.99	-21.
TUT	PAGO PAGO	SP	AWP	1	0.44	0.42	-1042.

FILM